



MP MASTER



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DYNATECH NEVADA, INC.

DYNATECH NEVADA — MEDICAL ELECTRONICS
EXACT ELECTRONICS — FUNCTION GENERATORS
SIGNAL SOURCES

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INSTRUCTION MANUAL

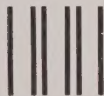
MODEL 605-254

PROGRAMMABLE WAVEFORM GENERATOR

Port mfg in
late 70's early 80's
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Bought Exact Co. in 1983
Dyna-Tech Nevada
Exact Electronics
City, Nevada
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SECTION 2

INTRODUCTION

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SECTION 2

2.1.0 INTRODUCTION

The Exact models 605 and 606 programmable waveform generators were designed to fulfill the need for accurate waveform generation, controlled by an external system or controller such as a digital computer. These generators can be completely controlled for Amplitude, Frequency, Function, Triggering, Offset, and Start Phase by an external source. The external programming source can be a contact closure such as a rotary switch or a relay. It can be a signal from TTL or DTL logic systems or it can be any other electrical signal within the operating range of the program inputs. The external programming source can be electrically isolated from the generator's circuit common. The Model 605 has provisions for locally controlling all functions, frequencies and amplitudes as well as external or remote mode.

The program inputs are on the rear panel in a single 50-pin receptacle. All other generator inputs and outputs "SYNC, VCF, etc" are also available on the rear of this 3 1/2" high 19 inch wide package. The part number for the mating plug to the 50-pin receptacle is Amphenol 57-30500. (Exact PN I3I0064).

This manual is an attempt to provide complete information on the specifications, operational procedures, circuit description, calibration, parts list, schematics, etc. of the Exact models 605 and 606. The information in this manual remains the property of Exact Electronics, Inc. and shall not be used or copied without the express permission of same. Patent Pending.

SECTION 3

SPECIFICATIONS

AND

VERIFICATION OF SPECIFICATIONS PROCEDURE

3.1.0 SPECIFICATIONS

WAVEFORMS

Sine, square, triangle, ramp, pulse, inverted.

MODES OF OPERATION

Run, gate, trigger.

DYNAMIC FREQUENCY RANGE

0.001 Hz to 1.11 MHz (Local control).

0.001 Hz to 1.66 MHz (Remote control).

3 digit resolution in 9 decade ranges.

FREQUENCY ACCURACY

Within $\pm(1\%$ of setting +1digit) 0.01 Hz to 100 KHz.

Within $\pm(2\%$ of setting +1digit) 0.001 Hz to 0.01 Hz.

Within $\pm(2\%$ of setting +1digit) 100 KHz to 1.11 MHz.

FREQUENCY STABILITY

0.04% of setting for 10 minutes.

0.2% of setting for 24 hours.

VCF INPUT (Voltage controlled frequency)

5V for 1600: 1 frequency control.

Usable from DC to 1 MHz.

SINE FREQUENCY RESPONSE

Within ± 0.1 dB to 100 KHz.

Within ± 0.5 dB to 1.11 MHz.

SINEWAVE DISTORTION

$< 0.5\%$ to 100 KHz.

No harmonics < 30 dB down to 1.11 MHz.

SQUAREWAVE

Rise and falltimes < 100 nsec.

Abberations $< 5\%$.

TRIANGLE NON-LINEARITY

$< 1\%$ to 100 KHz.

$< 5\%$ to 1.11 MHz.

MAIN OUTPUT

50 Ohm impedance.

1 mV to 10 V P-P into 50 Ohms.

2 mV to 20 V P-P unloaded.

3 digit resolution in 4 decade ranges.

60% overrange capability under remote control (slewing rates prevent overranging frequency and voltage simultaneously above 100 KHz).

AMPLITUDE ACCURACY

Within $\pm(1\%$ of programmed amplitude +1 digit) 0.001 Hz to 100 KHz.

Within $\pm 5\%$ of programmed amplitude 100 KHz to 1.11 MHz.

AMPLITUDE STABILITY

0.05% for 10 minutes.

0.2% for 24 hours.

DC OFFSET

Decreases programmed waveform to one-half its programmed amplitude and offsets it to maintain one peak at zero volts.

DC OFFSET INPUT

+1 V input results in -1 V offset in programmed output on 1 to 9.99 V range.

Voltage range selection attenuates offset and signal equally.

DC OFFSET STABILITY

0.01% for 24 hours.

GATE/TRIGGER INPUT

10K Ohm input impedance.

TTL, DTL compatible.

1.2 V required to Gate/Trigger.

DC coupled.

SYNC OUTPUT

Approx. 4 V P-P squarewave.

Approx. 100 Ohm output impedance.

PHASE LOCK INPUT

5 V P-P input will synchronize the 605 and 606 when the frequencies are within 1% .

TRIANGLE MONITOR OUTPUT

Approx. 10 V P-P.

Approx. 600 Ohm output impedance.

PROGRAMMING INPUTS

Function	Inputs	Code
Frequency decade	4	BCD
Frequency multipliers	12	BCD 3 digits
Voltage decade	2	Binary
Voltage multipliers	12	BCD 3 digits
Waveform	4	Binary
Waveform polarity	1	Binary
Fixed DC offset	1	Binary
Run, gate, trigger modes	2	Binary
Programming common	1	

TTL, DTL compatible.

Current sink <1 mA.

Programming time < 0.5 millisecond.

POWER REQUIREMENTS

Voltage: 117 VAC $\pm 10\%$ or 220 VAC $\pm 10\%$.

Frequency: 50 to 400 Hz.

DIMENSIONS

8.9 cm high by 43.2 cm wide by 34.3 cm deep.

Adaptors supplied for 19" rackmounting.

NOTE

Unless otherwise specified, all specifications apply at 25°C $\pm 5^\circ\text{C}$ ambient after a 30 minute warmup with amplitude and frequency multipliers set between 10% and 100% of range. The Main output must be terminated into 50 ohm.

3.2.0 VERIFICATION OF SPECIFICATIONS

The following is a list of test equipment required to validate the specifications of the Models 605 and 606 Programmable Waveform Generators. Test equipment of the accuracy equal to or better than the following list is acceptable for specification validation.

Oscilloscope, D.C. to 50 MHz (Tektronix Model 544)

Plug-In Differential Comparator 10 millivolts per centimeter sensitivity (Tektronix Type W)

Counter/Timer .1 μ sec time base, DANA 8010B

DVM .01% Accuracy, DANA 4300

Harmonic Distortion Analyzer less than .1% residual distortion (Hewlett Packard Model 333)

Spectrum Analyzer 10KHz to 100MHz (Nelson Ross plug-in for Type 544)

To proceed with verification of specifications, program the generator as follows:

800Hz on the 100 to 999Hz range, free running Normal phase sine wave of 8.00V P-P with no offset and the delta frequency control to CAL, Model 605 only. The Model 605 can be locally programmed for the same conditions.

3.2.1 FREQUENCY STABILITY

Connect the output of the generator to the frequency counter and observe that the frequency remains within .04% for ten minutes or $\pm .5\mu$ sec time interval.

3.2.2 FREQUENCY ACCURACY

Frequency should be 800Hz within 1% + 1 digit or 809Hz to 791Hz.

Reprogram for 400Hz, frequency should be within 1% + 1 digit or 405Hz to 395Hz

Reprogram for 200Hz, frequency should be within 1% + 1 digit or 203Hz to 197Hz

Reprogram for 100Hz, frequency should be within 1% + 1 digit or 102Hz to 98Hz

Reprogram for 880Hz, frequency should be within 1% + 1 digit or 889.8Hz to 870.2Hz

Reprogram for 840Hz, frequency should be within 1% + 1 digit or 849.4Hz to 830.6Hz

Reprogram for 820Hz, frequency should be within 1% + 1 digit or 829.2Hz to 810.8Hz

Reprogram for 810Hz, frequency should be within 1% + 1 digit or 819.1Hz to 800.9Hz

Reprogram for 808Hz, frequency should be within 1% + 1 digit or 817.1Hz to 798.9Hz

Reprogram for 804Hz, frequency should be within 1% + 1 digit or 813Hz to 795Hz

Reprogram for 802Hz, frequency should be within 1% + 1 digit or 811Hz to 793Hz

Reprogram for 801Hz, frequency should be within 1% + 1 digit or 810Hz to 792Hz

Reprogram frequency for 800Hz, set Decade Multiplier to the bottom range, that is the 1 to 9.99mHz range. Verify the frequency as 8mHz $\pm 2\%$ + 1 digit or from 8.17mHz to 7.83mHz. Program up one range and verify the frequency as 80mHz $\pm 1\%$ + 1 digit or 80.9Hz to 79.1Hz. Program up one range and verify that the frequency is 800mHz $\pm 1\%$ + 1 digit or 809mHz to 791mHz. Program up one range and verify that the frequency is 8Hz $\pm 1\%$ + 1 digit or 8.09Hz to 7.91Hz. Program up one range and verify that the frequency is 80Hz $\pm 1\%$ + 1 digit or 80.9Hz to 79.1Hz. Program up one range and verify that the frequency is 800Hz $\pm 1\%$ + 1 digit or 809Hz to 791Hz. Program up one range and verify that the frequency is 8KHz $\pm 1\%$ + 1 digit or 8.09KHz to 7.91KHz. Program up one range and verify that the frequency is 80KHz $\pm 1\%$ + 1 digit or 80.9KHz to 79.1KHz. Program up one range and verify that the frequency is 800KHz $\pm 2\%$ + 1 digit or 817KHz to 783KHz.

3.2.3 AMPLITUDE ACCURACY (Note: Output must be properly terminated in 50.0Ω)

Reprogram generator for frequency of 800Hz and using comparison oscilloscope, check the amplitude accuracy at 8.00V P-P into 50.0Ω to be within $\pm 1\%$ + 1 digit or 8.09V to 7.91V. Reprogram output voltage for 4.00V and check that amplitude is within $1\% \pm 1$ digit or 4.05V to 3.95V. Reprogram output voltage for 2.00V P-P and check to see that amplitude is within $1\% \pm 1$ digit or 2.03V to 1.97V. Reprogram for 1.00V P-P output and check to see that amplitude is within $1\% + 1$ digit or 1.02V to .98V. Reprogram for output voltage of 8.80V P-P and check to see that amplitude is within $1\% + 1$ digit or 8.898V to 8.702V. Reprogram for 8.4V and check to see that output is within $1\% + 1$ digit or 8.494V to 8.306V. Reprogram for 8.20V P-P and check to see that amplitude is within $1\% + 1$ digit or 8.292V to 8.108V. Reprogram for 8.10V P-P and see that output amplitude is within $1\% + 1$ digit or 8.191V to 8.009V. Reprogram output voltage for 8.01V P-P and check to see that amplitude is within $1\% + 1$ digit or 8.10V to 7.92V. Reprogram output amplitude for 8.02V P-P and see that amplitude is within $1\% + 1$ digit or 8.11V to 7.93V. Reprogram for 8.04V P-P and see that amplitude is within $1\% + 1$ digit or 7.950V to 8.13V. Reprogram for 8.08V P-P and check to see that amplitude is within $1\% + 1$ digit or 8.171V to 7.989V. Return program to 8.00V P-P and program generator for frequency of 999KHz and check to see that amplitude is within 5% or 8.40V to 7.60V.

3.2.4 SINE FREQUENCY RESPONSE

Program generator for 9.99KHz sine wave of 8.00V P-P, measure amplitude accurately and record. Program generator for 99.9KHz sine wave and verify that amplitude is within .1db (1.14% or 90mv) of reading obtained at 9.99KHz. Program generator for frequency of 999KHz and measure amplitude to verify that it is within .5db (5.6% or 448mv) of the value obtained at 9.99KHz.

3.2.5 AMPLITUDE STABILITY

Program generator for frequency of 800Hz and an output amplitude of 8.00V P-P, measure amplitude and record and then again at ten minutes and check to see that amplitude is within .05% (4mv) of reading obtained previously.

3.2.6 SINE WAVE DISTORTION

Program generator for a sine wave output of 9.99V P-P at a frequency of 9.99KHz. Connect distortion analyzer to the main output jack and measure sine distortion of less than .5%. Reprogram generator for frequency of 99.9KHz and measure sine distortion of less than .5%. Reprogram generator for frequency of 999KHz. Connect Spectrum Analyzer to Main Output jack and measure harmonic content. Observe no harmonics less than 30db down.

3.2.7 SQUARE WAVEFORM

Program generator for 999KHz square wave positive or negative of 9.99V P-P. Connect main output through 50Ω coaxial cable terminated into 50Ω to the oscilloscope. Observe

3.2.7 (Continued)

rise time and fall time of square is less than 100ns between 10% to 90% points. Observe overshoot and ringing is less than 5% of P-P amplitude (.50V ringing or overshoot).

3.2.8 TRIANGLE LINEARITY (Refer figure 3.2.8)

Connect the Main Output to a differential plug-in with 50 Ω coaxial cable terminated in 50 Ω . Adjust oscilloscope to obtain one-half cycle triangle across horizontal grid on oscilloscope CRT. Set differential plug-in sensitivity to 20mv per centimeter. Adjust comparison voltage until the slope of the triangle waveform intersects the mid-scale horizontal grid line at the second major mark as shown below.

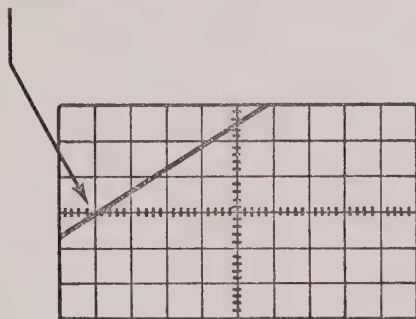


FIGURE 3.2.8

Record reference voltage using DVM accurate to 1mv. Adjust comparison voltage until slope of triangle intersects next major horizontal grid mark. Record accurately the new reference voltage. Repeat to obtain as many points as desired. Calculate linearity and observe linearity is 99% or better to 100KHz, 95% or better to 1.09MHz. Beware of oscilloscope inadequacies above 100KHz.

SECTION 4

OPERATING INSTRUCTIONS

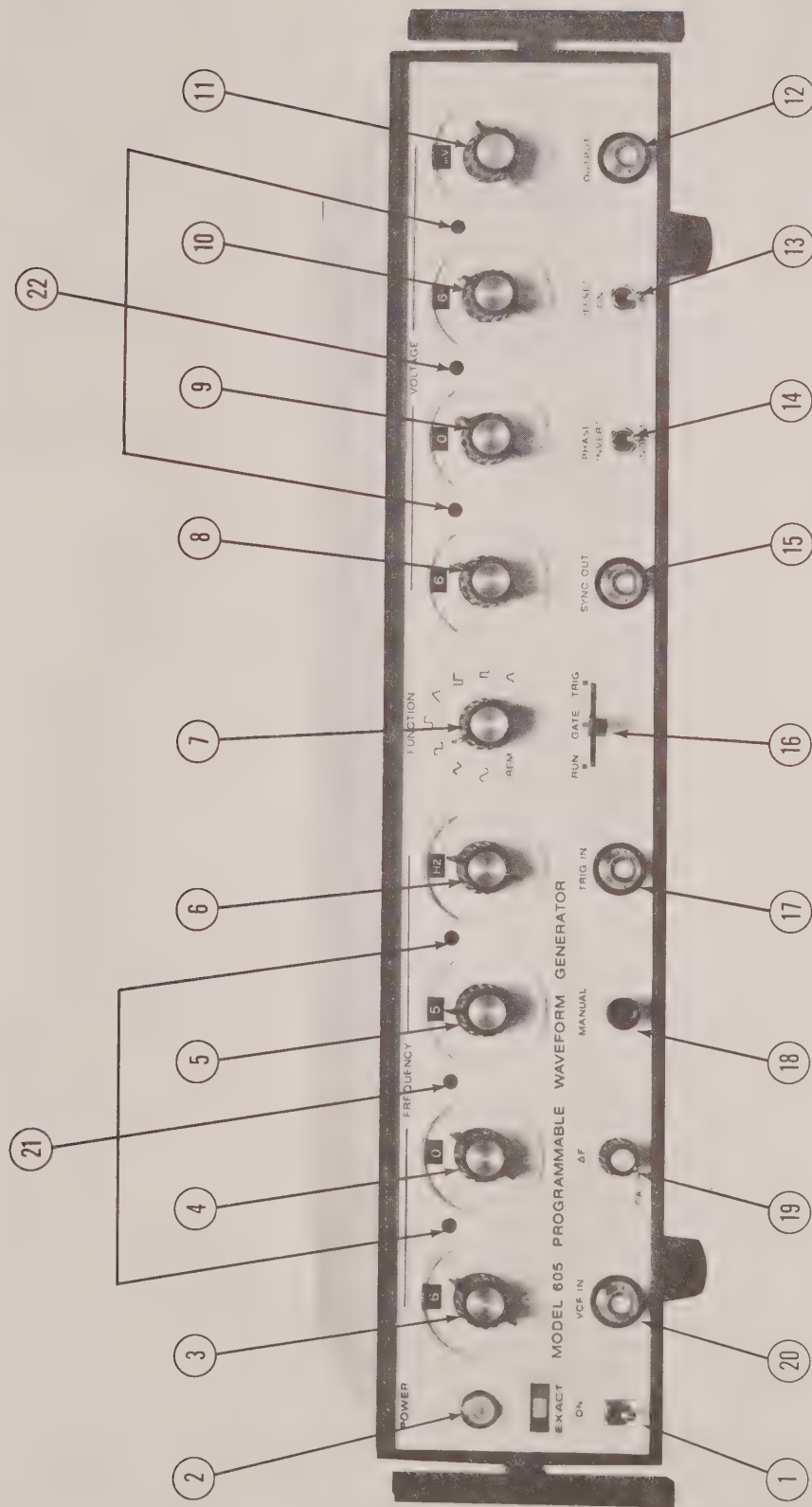


FIGURE 4.1.1
FRONT PANEL MODEL 605

4.1.0 FRONT PANEL FAMILIARITY (Figure 4.1.1)

1. Power On/Off switch - turns on input power to instrument.
2. Pilot Lamp - indicates input power On.
3. Frequency Multiplier - hundreds digit.
4. Frequency Multiplier - tens digit.
5. Frequency Multiplier - units digit.
6. Frequency Decade range selector - allows operation over nine decade frequency range.
7. Function selector - selects waveform to appear at the output connectors.
8. Voltage Multiplier - hundreds digit.
9. Voltage Multiplier - tens digit.
10. Voltage Multiplier - units digit.
11. Voltage Decade range selector - allows operation over four decade voltage range.
12. Output connector - allows 50 Ω output impedance for generated waveform.
13. Offset control - decreases program waveform to 1/2 programmed amplitude and offsets same to a level equal to its peak amplitude so that one peak is maintained at 0 volts.
14. Phase control - provides for 180 degree phase inversion of output waveform.
15. Sync output connector - provides square waveform for synchronizing other equipment to the generator.
16. Trigger mode control - selects free running, gated, or triggered operation.
17. Trigger input connector - accepts gating or trigger signals.
18. Manual Trigger control - allows manual gating or triggering of generator.
19. Delta Frequency control - allows vernier adjustment of frequency.
20. VCF input connector - accepts analog voltage for control of generated frequency.
21. Automatic decimal point indicators - operated by the Frequency Decade range control.
22. Automatic decimal point indicators - operated by the Voltage Decade range control.

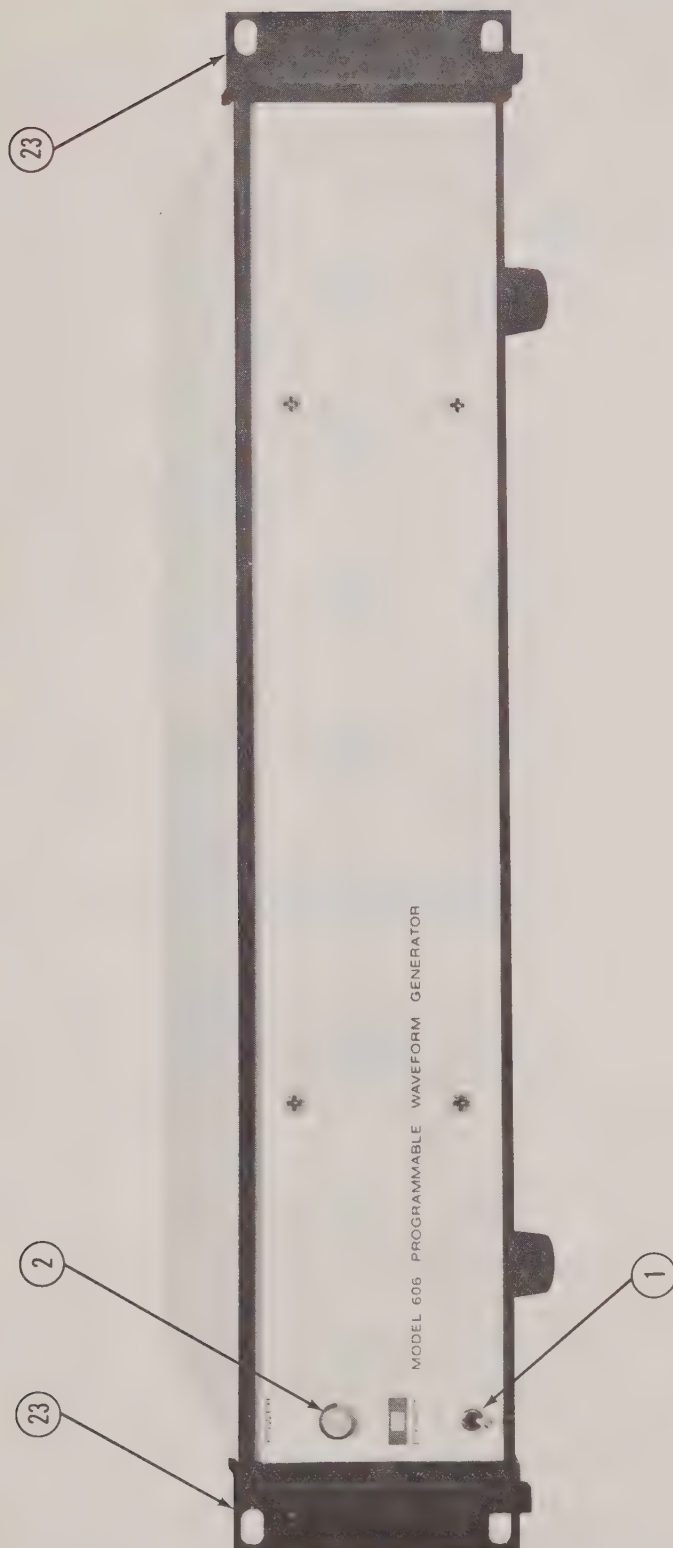


FIGURE 4.1.2
FRONT PANEL MODEL 606

4.1.2 FRONT PANEL FAMILIARITY (Figure 4.1.2)

1. Power On/Off switch - turns on input power to instrument.
2. Pilot Lamp - indicates input power On.
3. Rack mounting - standard equipment.

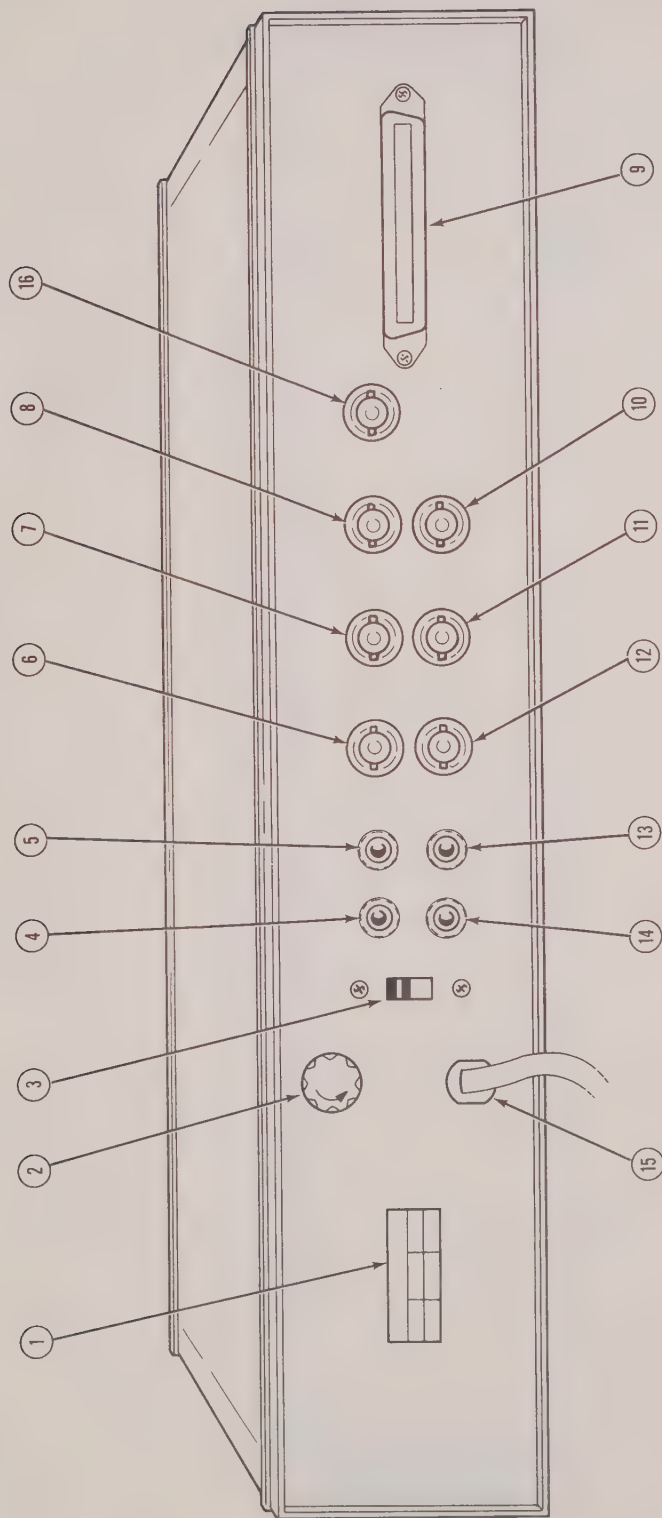


FIGURE 4.2.1
REAR PANEL MODEL 605-606

4.2.0 REAR PANEL FAMILIARITY (Refer figure 4.2.1)

1. Fuse data chart - shows requirements for operation at 115 or 220 volts.
2. Fuse holder - allows easy replacement in the event of fuse failure.
3. Line voltage selector - allows instrument operation from 110 or 220 volts AC.
4. Circuit Common connection - allows floating Circuit Common operation of instrument.
5. Programming Common connection - allows floating operation of the Programming circuitry.
6. Output connector - main output of generator.
7. DC Offset input connector - accepts external analog signal for programming D.C. offset.
8. Sync output connector - provides signal for synchronizing other equipment such as oscilloscopes, etc.
9. Programming input connector - accepts program inputs for remote control of the generator.
10. Trigger input connector - accepts input signals for gating or triggering of generator.
11. VCF input connector - accepts wideband AC or DC input for analog programming of generator frequency.
12. Triangle Monitor connector - provides constant monitor of triangle or ramp waveform generated in the instrument.
13. Chassis ground connection - provides for grounding of program common.
14. Chassis ground connection - provides for grounding of circuit common.
15. Line cord - accepts input power of the instrument.
16. Phase lock - accepts input synchronizing signal.

4.3.0 PROGRAMMING REQUIREMENTS

The circuitry at the programming inputs consists of a single transistor with a diode switching bridge on the base input.

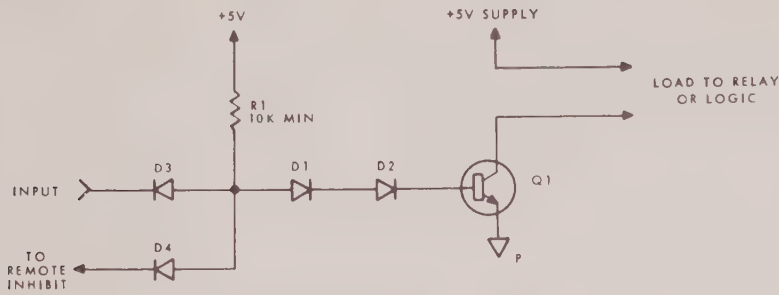


FIGURE 4.3.1

The transistor Q1 is used as a saturated switch for operation of reed relays and also as direct input for the TTL logic in the instrument. Resistor R1 provides the necessary base current for transistor Q1 through diodes D1 and D2. As either the input or the remote/inhibit bus is held low (programming ground or up to -50V), the current supplied from R1 is shunted out through the input diode D3 and D4. Without base current for Q1, collector current does not flow, and the relay or logic system is not energized. As the input is held positive (above 1.4V nominal), current from R1 begins to flow through D1 and D2 turning on Q1's collector current and activating its relay or logic circuitry. Some of the possible combinations of circuitry that can be used to operate the inputs are contact closure, DTL, TTL, direct voltage application and etc. One requirement of programming sources is that it must be capable of holding the low level state while sinking the 1 milliamp (nominal) of current being supplied by R1 (refer figure as previous). Maximum value of resistance to hold the input to a low stage should be 1.6KΩ.

An almost limitless list of combinations exists with the inputs' capability of handling ±50V DC and the switch point being at +1.2V nominal, in reference to the programming common. Some combinations are shown below:

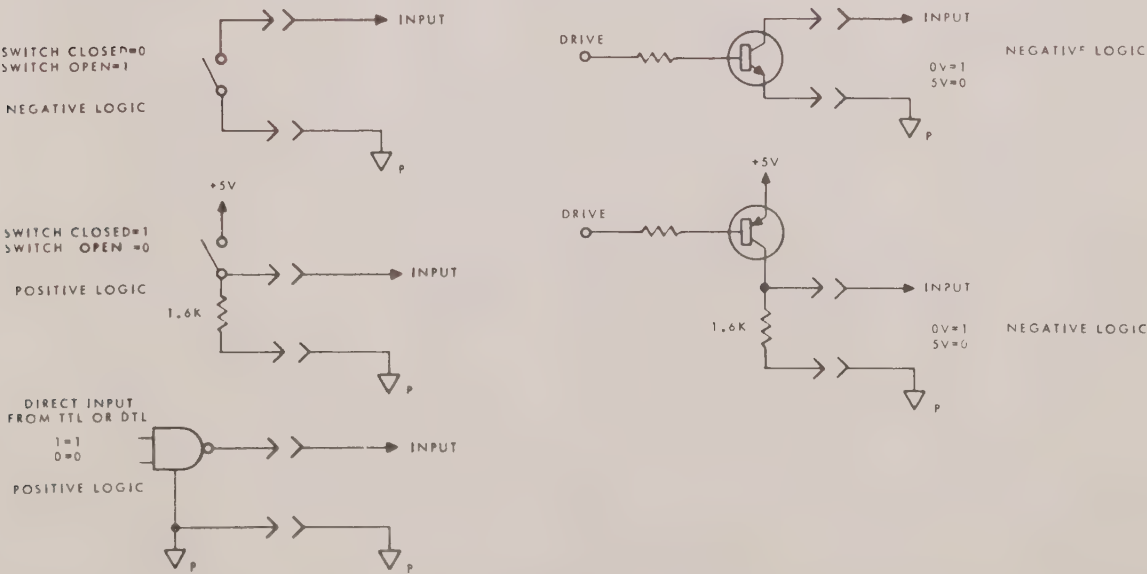


FIGURE 4.3.2

4.4.0 PROGRAMMING TABLES

The Models 605 and 606 have thirty-eight active inputs for programming output waveforms. With a logical "0" being defined as $+0.4V$ or less and logical "1" being defined as $+2.4V$ or more, a truth table can be shown for generator control in response to logical "0's" and "1's". In the Model 605, the inputs and controls are grouped into three groups so that any one of the three groups can be controlled remotely or locally. Any group can be operated in either control mode without affecting the others. The three groups are as follows: frequency, function (includes trigger mode, invert and offset), and voltage. Of the three groups, "frequency" has a total of sixteen external inputs. "Function" has eight inputs and "voltage" has fourteen inputs.

- 4.4.1 Of the sixteen inputs listed under "Frequency", four are used to control the decade range and twelve are used to control the multiplier.

The decoding for the decade range is as follows:

Decimal Eq.	Pin Number for Programming Input Connector				Frequency Range
	43	42	41	40	
0	0	0	0	0	1 - 10 mHz
1	0	0	0	1	10 - 100 mHz
2	0	0	1	0	100 - 1000 mHz
3	0	0	1	1	1 - 10 Hz
4	0	1	0	0	10 - 100 Hz
5	0	1	0	1	100 - 1000 Hz
6	0	1	1	0	1 - 10 KHz
7	0	1	1	1	10 - 100 KHz
8	1	0	0	0	100 - 1000 KHz

Binary Weight	8	4	2	1
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Binary weight and decimal equivalents apply to standard 1-2-4-8 BCD or straight binary only.

4.4.1 (Continued)

The decoding for the multiplier is as follows:

Decimal Eq.	Pin Number Program Input Connector															
	28	29	30	31		32	33	34	35		36	37	38	39		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
100	0	0	0	1	10	0	0	0	1	1	0	0	0	1		
200	0	0	1	0	20	0	0	1	0	2	0	0	1	0		
300	0	0	1	1	30	0	0	1	1	3	0	0	1	1		
400	0	1	0	0	40	0	1	0	0	4	0	1	0	0		
500	0	1	0	1	50	0	1	0	1	5	0	1	0	1		
600	0	1	1	0	60	0	1	1	0	6	0	1	1	0		
700	0	1	1	1	70	0	1	1	1	7	0	1	1	1		
800	1	0	0	0	80	1	0	0	0	8	1	0	0	0		
900	1	0	0	1	90	1	0	0	1	9	1	0	0	1		
X00	1	0	1	0	X0	1	0	1	0	X	1	0	1	0		
Binary Weight	8	4	2	1		8	4	2	1		8	4	2	1		

Binary weight and decimal equivalent apply to standard 1248 BCD codes only.

- 4.4.2 The eight inputs used to program functions can be broken down into several groups, some of which have only a single function as compared to others which are used in a sequence. The groups are trigger mode control (two inputs), polarity inversion (one input), fixed offset (one input), and waveform (four inputs).

4.4.2 (Continued)

The decoding table for the trigger mode control is as follows:

Decimal Eq.	Pin Number of Program Input Connector		
	27	26	
0	0	0	Inhibit External Triggering (Avail. as Option)
1	0	1	Trigger
2	1	0	Gate
3	1	1	Run

Binary Weight	2	1
---------------	---	---

The decoding for the polarity inversion input is as follows:

Decimal Eq.	Pin Number of Program Input Connector		
	5		
0	0		Normal Output Polarity
1	1		Inverted Output

Binary Weight	1
---------------	---

The decoding for the fixed offset input is as follows:

Decimal Eq.	Pin Number of Program Input Connector		
	3		
0	0		Fixed Offset
1	1		Normal Waveform

Binary Weight	1
---------------	---

4.4.2 (Continued)

Decoding for the waveform inputs is as follows:

Decimal Eq.	Pin Number of Program Input Connector				
	4	44	1	2	
8	1	0	0	0	Sine
9	1	0	0	1	Triangle
10	1	0	1	0	Normal Square
11	1	0	1	1	INV Square
14	1	1	1	0	INV Pulse
15	1	1	1	1	Normal Pulse
0	0	0	0	0	90 Degree Sine
5	0	1	0	1	Ramp

Binary Weight	8	4	2	1
---------------	---	---	---	---

4.4.2 (Continued)

The decoding table for the "voltage" multiplier is as follows:

Decimal Eq.	Pin Number Program Input Connector													
	6	7	8	9		10	11	12	13		14	15	16	17
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	1	10	0	0	0	1	1	0	0	0	1
200	0	0	1	0	20	0	0	1	0	2	0	0	1	0
300	0	0	1	1	30	0	0	1	1	3	0	0	1	1
400	0	1	0	0	40	0	1	0	0	4	0	1	0	0
500	0	1	0	1	50	0	1	0	1	5	0	1	0	1
600	0	1	1	0	60	0	1	1	0	6	0	1	1	0
700	0	1	1	1	70	0	1	1	1	7	0	1	1	1
800	1	0	0	0	80	1	0	0	0	8	1	0	0	0
900	1	0	0	1	90	1	0	0	1	9	1	0	0	1
X00	1	0	1	0	X0	1	0	1	0	X	1	0	1	0
Binary Weight	8	4	2	1		8	4	2	1		8	4	2	1

Binary weight and decimal equivalent apply to standard 1248 BCD codes only.

The decoding for the "Voltage Decade" is as follows:

Decimal Eq.	Pin Number of Prog. Input		
	19	18	
0	0	0	1-10mv
1	0	1	10-100mv
2	1	0	100-1000mv
3	1	1	1-10V
Binary Weight	2	1	

- 4.4.3 Pin #50 of the program input connector is the common return for all programming input connections. Pin #25 of the program input connector is a supply of +5V suitable for supplying logical "1's" to inputs held low with resistors.
- 4.4.4 Representative program might be as follows: generate a free running 925Hz inverted triangle (no offset) at 678mv P-P.

Frequency Group

	Pin Number Program Input Connector															
	28	29	30	31	32	33	34	35	36	37	38	39	43	42	41	40
Binary Weight	8	4	2	1	8	4	2	1	8	4	2	1	8	4	2	1
Necessary Input	1	0	0	1	0	0	1	0	0	1	0	1	0	1	1	0
Actual Output	9				2				5				X 100 to 1000Hz			
	Range = 925Hz															

Function Group

	Pin Number of Program Input Connector							
	27	26	5	3	4	44	1	2
Binary Weight	2	1	1	1	8	4	2	1
Necessary Input	1	1	1	1	1	0	0	1
	Run	Inv.	No Offset	Triangle				

Voltage Group

	Pin Number of Input Connector															
	18	19	6	7	8	9	10	11	12	13	14	15	16	17		
Binary Weight	2	1	8	4	2	1	8	4	2	1	8	4	2	1		
Necessary Input	1	0	0	1	1	0	0	1	1	1	1	0	0	0		
Actual Output	100-1000mv Range		X	6					7					8	= 678mv	

In the Model 605, it is necessary to set the frequency decade control, the function selector, and voltage to the Remote position for complete remote programming as is the foregoing.

4.4.5 LOCAL OPERATION, MODEL 605

In order to generate the free-running 925Hz inverted triangle with no offset at 678mv P-P (as in the previous example), it is necessary to preset the control knobs as follows: With the power switch on, preset the frequency multiplier to the digits 925 as indicated in the program and rotate the decade selector until the automatic decimal point indicates that you have selected 925Hz. Select Triangle on the function selector and also set the phase switch to the Inverted position. Preset the trigger mode selector to Run for free-running waveform. Next it is necessary to select the digits 6, 7 and 8 on the voltage multiplier and then rotate the voltage decade selector until the automatic decimal indicator indicates that you have selected 678mv. Monitoring the output connector at this point and time should verify that indeed you have generated the required waveform as set forth in the program.

SECTION 5

CIRCUIT DESCRIPTION

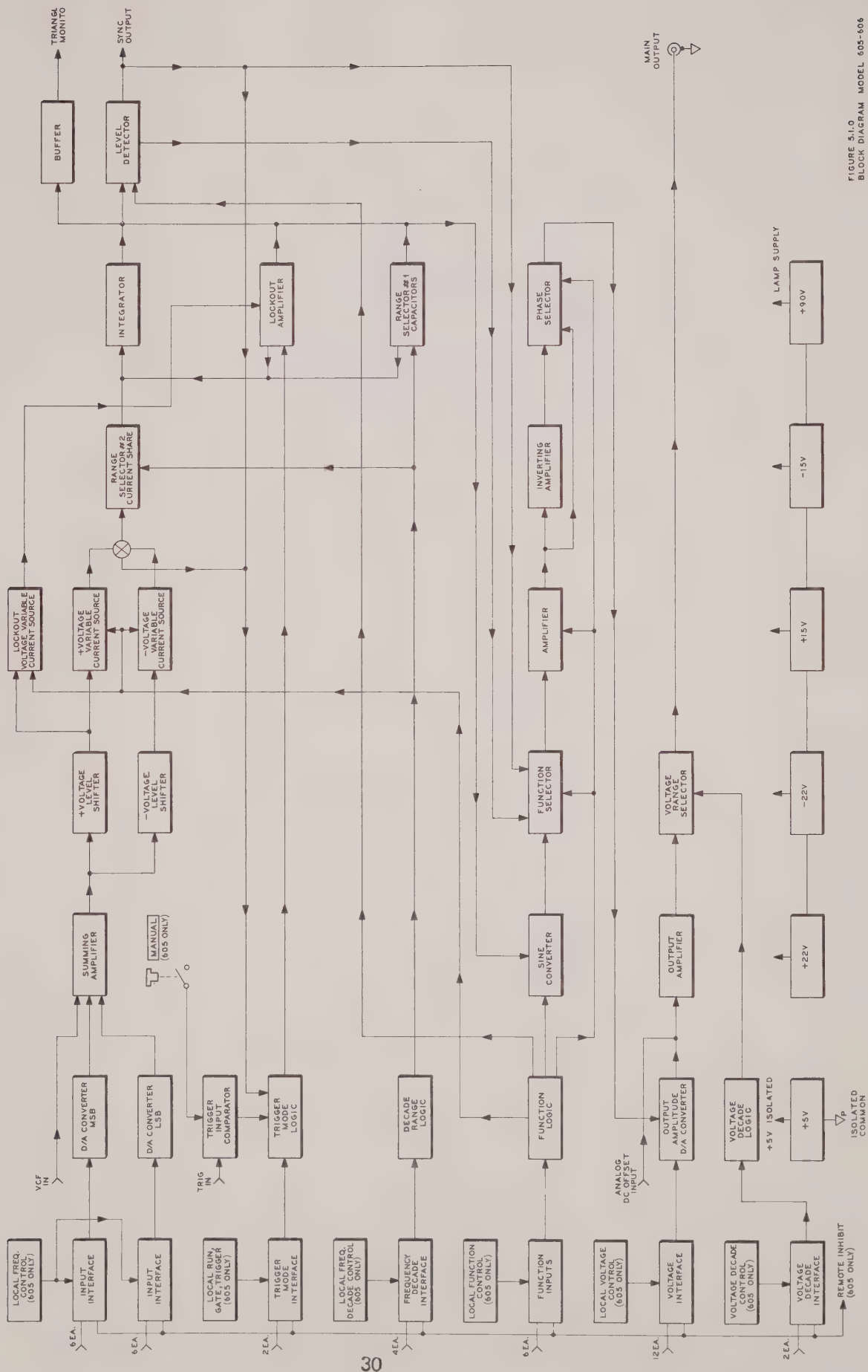


FIGURE 5.1.0
BLOCK DIAGRAM MODEL 605-606
11-18-70

5.1.0 BLOCK DIAGRAM (Refer Figure 5.1.0)

The basic generator loop utilized in this generator is an operational integrator and a bi-stable level detector. The bi-stable level detector switches integrator input currents at predetermined points on the integrator output. The loop generates a constant amplitude triangle whose frequency is proportional to the integrator input current and integrator feedback capacitance. Decade values of frequency are selected by decade selection of feedback capacitance and for the lower ranges decade selection of current sharing network on the input of the integrator. Variable frequency adjustment is accomplished by having voltage variable current sources feeding into the current switch at the input of the integrator. These voltage variable current sources are in actuality operational current sources driven by two operational voltage level shifters which are driven by the single summing amplifier. The summing amplifier is used to provide an external analog programming of frequency (VCF) or it is used to sum the outputs of the two amplifiers used to provide the digital analog conversion. The digital to analog conversion is done in two sections so that each section can be operated at a higher current level and therefore neither one has to operate at extremely low current levels. D to A conversion is done through a series of relay closures providing different resistance value for each weighting of an input. The relay activation is provided by the interface circuitry which is a saturated transistor switch operated by an external input signal.

The basic generator loop (the integrator and level detector) by nature provides a triangular waveform and a square waveform that can be processed and used as output signals to provide two waveforms. The triangular wave can be processed through the sine converter and provide a sinusoidal waveform. All three of these waveforms then are supplied to the function selector which is controlled by the function logic circuitry. The function logic circuitry decodes the input of the six function inputs such that each waveform can be provided for a given input condition at the function inputs. The output of the function selector is applied to the amplifier which provides a constant output amplitude and at the same time provides for the offset half amplitude function. The output of this amplifier is fed to the phase selector and also the inverting amplifier. The output of the inverting amplifier is fed to the phase selector. Phase selector is controlled by the function logic so that either output phase from the main generator loop can be provided to the output amplifier. The output of the phase selector is fed to the output amplitude D to A converter. The output D to A converter is a series of relays and different values of input resistors for the output amplifier. These relays are activated by the output amplitude interface circuitry which is the input circuitry for the external programming. The output amplifier accepts the signals from the output D to A converter and converts them to output voltage for the voltage range selector. The output amplifier provides the power necessary for driving a 50Ω output impedance. Voltage range selector is a series of 20db attenuator pads. These attenuator pads are controlled by the voltage decade logic circuitry. The voltage decade logic circuitry decodes the inputs from the voltage decade interface for selection of the correct voltage range. The interface circuitry provides conditioning for the external programming input signals.

There are six power supplies in the Models 605 and 606; one of the power supplies being a +5V supply that is completely isolated from the other power supplies. The +5V supplies

5.1.0 (Continued)

all the logic circuitry and interface circuitry associated with the external programming. The +22 and -22 supplies are used to provide voltage for the current sources and the output amplifier. The +15 and -15 are re-regulated from the +22V and -22V. They are used to provide operating voltages for other circuitry in the generator loop. +90V supply is used to power the pilot lamps and the automatic decimal point lamps in the instruments.

5.2.0 POWER SUPPLY (Refer Figure 8.2.1)

The power line voltage is fed to the instrument through Plug P100 to the protective fuse F100. The line switch S100 supplies line voltage to the operating voltage selector S101. S101 applies the voltage to the transformer in either a series or parallel arrangement depending on the line voltage available. The transformer T100 is used to step down the voltages to lower values for application to the rectifier filter combinations in the instrument. Diodes D100 and D105 in combination with capacitors C101 provide an unregulated voltage of approximately 9.8V to supply the integrated circuit regulator Q100. Q100 is a complete power supply inside an integrated circuit package. It contains its own reference, voltage supply, and error amplifier. Q105 is an external series pass transistor used to enhance the current carrying capabilities of Q100. R105 is a current sensing resistor used to supply current limiting voltages to the integrated circuit Q100. Resistive divider R100, R101 and R102 is used to provide the necessary feedback voltage to the error amplifier inside Q100. R101 provides for a small adjustment in the value of the output voltage. Diode D105 prevents any external application of negative voltage to any of the circuitry on the +5V programming power supply lines.

With all of the TTL logic and logic interface circuitry, etc. connected to the +5V power supply, an overvoltage would be somewhat catastrophic; therefore, a completely passive "Crowbar" circuit has been installed. Any overvoltage on the +5V power supply line in excess of 10% will cause Q115, a silicon control rectifier, to conduct and remain conducting until the overvoltage has been corrected. The power switch must be turned off and then on again to restore operation. SCR Q115 receives its gate current drive from transistor Q110. Transistor Q110 is operated as a saturated switch. It gets its base drive from tunnel diode D110. Tunnel diode D110 is biased near its peak point current by resistor R111 and adjustment R112. Resistor R110 is used to increase the amount of voltage drop across the base emitter junction so that it is adequate to turn on Q110. The programming supply +5V and its common are isolated from instrument common and also from line ground or chassis ground. If needed, these connections can be made through rear panel jacks J102 and J103. Rear panel jacks J101 and J100 also provide connection of circuit common which is also isolated to chassis ground.

Full wave diode bridge D120 along with filter capacitors C120 and C140 provides approximately $\pm 30V$ for the regulators that regulate to +22 and -22V. Integrated circuit Q120 is a power supply unit that contains its own reference error amplifier and etc. Transistor Q125 is used to enhance the current carrying capability of the integrated circuit. Resistor R125 provides the current sensing so that the integrated circuit can be used to provide current limiting. Feedback voltage for the error amplifier in the

5.2.0 (Continued)

integrated circuit is developed across voltage divider R126, R127 and R128. Adjustment R127 is used to provide a small amount of voltage adjustment for the +22V supply. Diode D125 provides protection against accidental applications of negative voltages to the +22V power supply line. The +22V supply is used as a reference for the discreet component regulator that generates the -22V. Divider R156, R157 and R158 applies this reference to the differential amplifier made up of transistors Q150 and Q155. The base of transistor Q150 is held at 0V by resistor R150. The output of the differential pair (which appears at the collector of Q150) is applied to the base of transistor Q140 through resistor R151. Capacitor C141 and resistor R142 are phase compensating networks for the regulator. The output of transistor Q140 is applied to resistor R145 which in turn is connected to the base of the series pass transistor Q145. The emitter of Q145 supplies the necessary output current through current sensing resistor R145 to the power supply output. Transistor Q160 is used to provide a feedback signal to the differential amplifier Q155 through diode D160. This turns power supply voltage off in the event of a current limit signal which is developed across R145. Feedback necessary for power supply operation is through resistor R158 which maintains the reference to Q155 at 0V when both the power supplies are equal and opposite. Adjustment R157 provides for small amount of adjustment in the output voltage of the -22V supply. Diode D160 prevents damage in the event of application of positive voltage to the -22V power supply line. To provide a very stable 15V supply, the +22V from regulator Q120 is applied to integrated circuit Q130 and is re-regulated. Q130 is a complete power supply in one integrated circuit; that is, it has its own reference, error amplifier, etc. Transistor Q135 is used to enhance the current carrying capabilities of the integrated circuit. Resistor R135 is a current sensing resistor used to provide current limit operation of the integrated circuit. Feedback necessary for closed loop operation is through resistive divider made up of R136, R137 and R138. Adjustment R137 is used to provide a small amount of variation in the value of the supply voltage obtained at +15V supply output. Diode D135 is used to prevent damage in the event of application of negative voltage to the +15V power supply line. Operational amplifier Q165 is used as an inverting amplifier with a gain of 1 to provide a negative 15V power supply that tracks very accurately the positive 15V power supply. Diode D165 is used to shift the level of the operational amplifier to a higher voltage for operation of the Darlington circuit made up of transistors Q170, Q175. The output of the series pass transistor Q175 is applied to the -15V line through current sensing resistor R175. Transistor Q180 is used to provide a feedback signal when current limit is reached. This feedback signal is applied to the input of the operational amplifier and reduces its output in the event of a current limit. Feedback necessary for closed loop operation is through R167, adjustment R166, and R165 to the +15V supply. Adjustment R166 is used to provide the small range of adjustment in the output voltage of the -15V supply. Diode D175 is used to prevent damage in the event of an application of the positive voltage to the -15V line. Diode D10, D11, D12 and D13, in conjunction with capacitor C10, are used to provide a supply of positive 90V DC. This supply is used to operate the instrument power on lamp and the automatic decimal point indicating lamps on the front panel of the Model 605.

5.3.0 GENERATOR LOOP CIRCUITRY (Refer Figure 8.2.2)

The integrator portion of the generator loop circuitry can best be described as an operational amplifier utilizing capacitors as feedback network, therefore can be termed an operational integrator. This operational amplifier has two signal paths, one covering the range DC to 100KHz and the other covering the range 100KHz and above. Transistor Q340 being a matched dual field effect transistor comprises the input circuitry for the low frequency path in the amplifier. This circuit is a differential amplifier whose outputs are applied to another differential amplifier made up of Q355, Q360. The voltage developed across voltage dividers R347 thru R351 and including R344 is used to offset the differential voltage between the two gate connections of the dual transistor Q340. The output of this second differential pair (the collector of transistor Q340) is applied to the base of one of the transistors used in the differential mixer (transistors Q365 and Q370). The input for the high frequency channel is transistor Q350. The signal from Q350 is applied to the other input of the differential mixer (the base of Q370). One polarity of output from the differential mixer (the collector of Q365) is applied to the base of Q375 through phase compensating network C365 and R366. Transistor Q375 inverts this signal and it becomes the same polarity as the opposite output of the differential mixer. These two signals are then connected together through bias diodes D375 and D370 and including resistor R370 to the output emitter followers transistors Q380 and Q385. The emitter followers Q380 and Q385 provide a very low value of output impedance for the operational amplifier. Diodes D371 and D376 provide short circuit protection for the output devices in this amplifier.

The feedback capacitors necessary to form the operational integrator from the operational amplifier is a matched set of capacitors C435A through C435E. For the higher ranges, a small variable capacitor with a parallel fixed capacitor (C436 and C437) is used. The input current for the integrator is applied to the current sharing networks. The current sharing networks are only used for the three lower ranges of the instrument. For all other ranges, a "short to summing junction relay" is turned on and the current is applied directly to the input of the operational integrator. Diodes D319A and B are a matched pair. Diodes D320A and B are also a matched pair. These four diodes are used to short the output of the integrator to the input and to lock out the Integrator-Level detector loop and stop operation of both. Diodes D315 and D316 are used to sink the current from the lock-out current source when it is not desired to lock out the integrator level detector loop. Differential pair Q315 and Q320 are used to control these diodes when the signal from the integrated circuit Q310 is present. Integrated circuit Q310 is wired as a flip-flop so that the generator can only be locked out after the level detector has changed states and the integrator is approaching zero volts. Either signal at the input to the integrated circuit Q310 (pins 1 and 2) can override the reset signal and provide for continuous running as when relay K302 is actuated or when gated through pin 1. Any command through the trigger input comparator is coupled through capacitor C303 and provides a short pulse to set the flip-flop and one cycle will be generated. When K301 is actuated and the input comparator is turned on, the generator continues to run as the flip-flop is held in that state. The flip-flop is allowed to reset after this gate signal is removed. The trigger comparator is an integrated circuit comparator with positive feedback applied

5.3.0 (Continued)

through R303 to R302. Diodes D301 and D300 protect the input of the integrated circuit comparator from large voltage swings possible at the input jack of the instrument. S304 provides a manual actuation of the input comparator so that an external voltage is not always needed to trigger or gate this generator. Diodes D302 and D303 provide the necessary operating voltages for the integrated circuit. Transistor Q305 provides the necessary 5V for operation of the Q310, the integrated circuit.

The level detector is a high-speed current mode switch whose input is differential pair Q395A and Q395B. This differential pair drives differential pair Q415 and Q430. The collectors of Q415 and Q430 are clamped by diodes. The collector output signals are also buffered by complimentary emitter followers Q405, Q410 for the collector of Q415, Q420 and Q425 for the collector of Q430. With the base of Q395B held at ground or zero volts, the switch point at the base of Q395A then becomes zero volts. The output of the integrator is fed through resistor R387 and high frequency peaking capacitors 385 and 386 to the base of the input transistor Q395A. Also connected to the input of the level detector is the switching bridge composed of diodes D390A, D390B, D391 and D392. The square signal present at the output of the complimentary emitter followers Q405 and Q410 then is applied to this switching bridge which selects either a positive or negative current to be fed to the input of the level detector. This forms the positive feedback necessary for bi-stable operation of the detector. The square wave signal that is applied to this switching bridge is also applied to the switching bridge at the input of the integrator that selects either positive or negative input current for the integrator. To analyze the operation of this detector one must assume that the output of the complimentary emitter follower Q405 and Q410 was at a positive state which selects a positive current for the level detector reference, and also a positive current for the integrator input. With this input, the output of the integrator is integrating in a negative direction. As the current through R387 (the input resistor to the level detector) reaches the same value as the current being supplied by R391 and R390 to the base of the input transistor Q395A, zero volts is reached and the level detector switches states to the other state which selects a negative input current for the integrator and a negative current through the switching bridge for the input of the level detector. In order that both polarities of the square wave are available for processing in the output amplifiers, the complimentary buffers Q420 and Q425 are provided. This buffer also provides a square wave for a synchronizing output signal.

5.4.0 D TO A CONVERTOR AND CURRENT SOURCES (Refer Figure 8.2.3)

In order to provide input current for the integrator and to provide voltage control of frequency, voltage variable current sources have been utilized. Diodes D281, D282, D283 and D280 form a switching bridge that allow the currents to be switched from negative to positive at the integrator input. The negative current source is applied to the integrator input at all times and the positive current source (which is of a value of 2 x the negative current source) can be switched on and the resultant current flow to the integrator input is equal and opposite to the value of the negative current

5.4.0 (Continued)

source. Operational amplifier Q275, transistor Q280 and transistor Q295 form an operational current source whose output is the collector of Q295 and the Drain of Q280. As the input voltage to the positive input of the operational amplifier is varied, the voltage across resistor R276 is varied. The current in the source of Q280 and the emitter of Q295 changes, varying the output of the current source. When K280 ramp reset relay is energized, resistor R280 is in the circuit and the current value of the current source is increased to approximately two times the normal value. This provides for a faster reset producing the 85 to 15 ramp-reset ratio. In order to provide level shifting and proper phase inversion for the correct polarity of drive signal, operational current source Q265 and Q270 has been provided. This current source shifts the level of the 0 to 4V available out of the summing amplifier to a +15 to +11V suitable for driving the Positive Current Source. In the same manner, operational current source Q245 (in conjunction with Field Effect Transistor Q250) provides a level shift to drive the negative current source. It takes the 0 to 4V available out of the summing amplifier and converts it from -15 to -11V suitable for input of the negative current source. The negative current source is an operational current source made up of integrated circuit Q255 and Field Effect Transistor Q260. Resistor R256 and adjustment R257 provide the operating current for transistor Q260 which is the output current of the current source. In the Triangle mode of operation, relay K260 is energized and resistor R260 and adjustment R261 are connected, increasing the value of current to maintain a symmetrical relationship for the triangle of 50% to 50%. Also being driven from the level shifted voltage generated by operational current source Q265 and transistor Q270 is the Lock-out current source which is comprised of integrated circuit Q285 and transistor Q290. This current source is used to supply a current to the lock-out diodes that is equal and opposite to the integrator input, thereby sinking all integrator input current and causing it to remain in a lock-out condition. In the Triangle mode of operation, relay K290 is energized and the value of the current output is controlled by parallel combination of resistor R293 (and its adjustment R292) and resistor R290 (and its adjustment R291).

Operational amplifier Q230 has been utilized as a summing amplifier to accept either signal from the D to A convertors or an external VCF input signal to drive the level shifting current sources. Relays K240, K241, K242 and K243 are used to provide a vernier adjustment for each decade range involving a different integrating capacitor. These relays switch in a very fine adjustment of the gain of the summing amplifier for each decade range. Balance adjustment R230 and its divider R231 through R233 is used to provide a balance for the offset voltage inherent in the integrated circuit operational amplifier. Frequency vernier adjustment R214 is also an input through summing resistor R213.

In order that no portion of the D to A convertor would have to operate at very low current level, it has been broken down into two sections with output weightings one decade apart. Operational amplifier Q205 has the highest weighting which is summed into the summing amplifier through R212. Operating at 1/10th the weighting is operational amplifier Q215 which is fed to the summing amplifier through resistor

5.4.0 (Continued)

R222. As each of the D to A convertor relays K185 and K203 is closed or opened, the output of the summing amplifier can be varied over its entire range with three digit resolution. Resistor R209 and adjustment R210 is used to provide frequency calibration. Resistor R219 and its adjustment R220 is also used to provide calibration at the low frequency end of the multiplier.

5.5.0 DECADE FREQUENCY CONTROL CIRCUIT (Refer figure 8.2.4)

The decade frequency control circuitry consists of the logic interface connections plus suitable decoding to convert a four-input BCD signal to eight lines for controlling the relays discussed previously in the generator loop circuitry. These relays control the current-sharing networks on the input of the integrator and the feedback capacitors for the integrator. The interface circuitry for the four external inputs that control the frequency decade consist of a NPN transistor used as a saturated switch and a diode switching bridge that supplies base current to the NPN transistor. Transistors Q525 through Q540 are the four saturated switches that comprise the four input BCD decade frequency control. The two diodes in series with the base lead of the transistor, for example diodes D526 and D525, provide noise immunity by increasing the amount of voltage required to saturate the NPN transistor. The two diodes D525 and D526, along with the base emitter drop of the transistor (Q525), raise the voltage required at the junction of the bias resistor R526 and the two series base diodes D525 and D526 to a potential of approximately 2.1V. At the input, such as pin 40, any voltage greater than +1.4V begins to reverse bias the input diode (D528) and the current flowing through it becomes 0 and all the current supplied by the bias resistor (R526) begins to flow through diodes D525 and D526, turning on transistor Q525. The same control over Q525 is exhibited by input diode D527. This diode is connected to the remote inhibit bus which holds the potential at the bias resistor and the transistor input point to less than .7V which does not allow the transistors to saturate. This effectively inhibits the action of all the remote inputs; therefore, it is dubbed remote inhibit bus. In the local control mode in the Model 605 only, the remote inhibit bus is held in a low state which deactivates all the external inputs and the transistors remain in an OFF condition. This allows the voltage at the collector load of the transistors to rise to the value of the positive supply voltage, providing a "one" input for integrated circuit Q550. Integrated circuit Q550 provides an "OR" function so that remote control in the Model 605 can be accomplished. The outputs of the four gates providing the four "OR" functions are fed to integrated circuit Q555. This integrated circuit provides a decimal output for a binary coded decimal input consisting of four inputs. Lamps I550 through I552 provide an automatic decimal point indication that allows direct reading of frequency from the front panel of the Model 605. The switch controlling these lamps is ganged with the decade frequency control switch. The bottom four ranges of the generator (the 1 millihertz to 1Hz range) share the same timing capacitor (the 10μfd capacitor) and utilize the current sharing networks to control the decade frequency. Therefore, these four lower signals are grouped together and fed to integrated circuit Q560 which controls the decoding in a manner that maintains the 10μfd capacitor connection while utilizing the current sharing networks for the different inputs

5.5.0 (Continued)

involved with the bottom four ranges. Integrated circuit Q565A, B and C control the current sharing network that utilizes the 2.15K resistor. Integrated circuits Q565D and Q570A and B control the current sharing network utilizing the 24.3K resistor. Integrated circuits Q575A and Q575D actuate the 10 μ fd trim relay which enables the variable resistor in the VCF summing amplifier. Q575B and Q575C activate the 10 μ fd relay. Q575A through D also provide a switching function for the CAL NORM switch. This switch defeats the 10 μ fd capacitor connection and the trim relay connection and instead actuates .01 μ fd relay and .01 μ fd trim relay so that timing of the lower frequency ranges of the instrument can be done at a higher frequency. Integrated circuit Q560A output signal actuates the short to summing junction relay, that is K320, which defeats all current sharing networks and allows full input current from the current sources to be applied to the integrator. The inverse of this signal, that is the 221 Ω relay, is actuated by integrated circuits Q570C and Q570D which inverts signal from Q560A. Integrated circuit Q585A and B provide phase inversion necessary to drive integrated circuits Q580B and C, Q590B and C for actuation of the 1 μ fd relay and the .1 μ fd relay. Also activated at the same time is integrated circuit Q580A, Q580D, Q590A and Q590D. These integrated circuits control the trim relays associated with the timing capacitors relays. Q585D provides a phase inversion necessary for operation of Q595B, Q595D while at the same time providing for the actuation of the .01 μ fd relay when the CAL NORM switch has been switched to the CAL position. The output of an integrated circuit Q595B and Q595C directly drives the .01 μ fd relay K440. Q595A and Q595D are parallel to drive the .01 μ fd trim relay. Activation of the 910pf relay is accomplished by integrated circuits Q600B and Q600C which are operated in parallel and driven from integrated circuit Q585C which inverts the signal.

5.6.0 FREQUENCY MULTIPLIER CONTROL CIRCUIT (Refer figure 8.2.5)

In order to activate the relays associated with D to A convertor used to drive the voltage variable current sources, the interface networks consisting of the saturated transistors as shown in schematic diagram are utilized. Twelve transistors are provided to activate the twelve relays in the D to A convertor. These transistors receive their base bias current from the bias resistors such as R460. Diodes D462 and D461 are used to provide noise immunity by boosting the input voltage required to saturate the transistor to approximately 2.1V. Diodes such as D190 connected across the relay coils prevent over-voltage from appearing at the collector of the transistors due to the reactive kickback in the relay. Input diodes D463 and D464 provide input capabilities for either the remote inhibit bus or the external controlling input. As the remote inhibit bus is held at a low state, the current supplied by the base current supply resistor is shunted through diodes such as D463. This does not allow the voltage at the anode of D462 to rise to 2.1V and does not allow the transistor to be activated. When the remote inhibit bus is in a positive state or in a remote condition, the external input signal, such as through diode D466, then has complete control over the transistor switch. When the remote inhibit bus is held low, such as in a local control mode, then the relay is allowed to be actuated through diodes such as D460 to the front panel controls such as S460.

5.7.0 AMPLIFIER AND INVERTING AMPLIFIER CIRCUITS (Refer figure 8.2.6)

The amplifier and inverting amplifier circuitry consists of two high-performance wide-band operational amplifiers. One is used to provide summing and gain conditioning for the sine waveform generated by diode bridge network, the triangle waveform generated from the integrator output, and the square waveforms generated from the level detector outputs. The inputs to the amplifier are selected by function selector circuitry. The output from the integrator, being a constant amplitude due to the fact that it is controlled by the level detector, can be processed directly through a simple summing network to the operational amplifier. The triangle also is fed to a series of four diode bridges which are arranged so that they provide equal break points along the triangular waveform creating a sinusoidal function of very low distortion with an output of the proper amplitude necessary for conditioning in the amplifier circuitry. As the input voltage is raised to any one of these diode bridges, the output current from that same bridge begins to raise until it reaches the maximum value of current supplied by the resistor potentiometer combination and then it becomes a constant current source. Each bridge is turned on at a successively higher level and, therefore, provides a peak value of the combination of all four bridges for an output current at the peak of the triangle. The square waves from the level detector are processed through input relays and a switching bridge which provide a constant output current level. The complimentary emitter follower buffer circuit consisting of Q1200 and Q1205 provides a continuously monitored output of the triangular wave generated at the integrator. The output of this buffer circuit is applied directly to the rear output connector through the output resistor R1208. The sine offset relay is used to provide a current equal and opposite to the offset generated at the integrator output when the generator is operated in a 90 degree sine output mode. The offset relay K700 is used to provide the fixed DC offset when the offset control is actuated. Also actuated at the same time the offset control is actuated is relay K755 which parallels the operational amplifier feedback resistor with a resistor of an equal amount, reducing the gain to one-half the original value. The output of this amplifier circuitry is applied directly to the input of the inverting amplifier which is operated at a gain of 1. Being an operational amplifier, it provides 180 degree phase inversion giving then two phases for processing in the amplitude selector. These two operational amplifiers are nearly identical with two signal paths in each amplifier. One signal path covers frequencies from DC to approximately 100KHz and the other signal path processes frequencies above 100KHz. The input circuitry for the low frequency path is a differential pair consisting of Q710, a matched pair of silicon transistors. Resistive divider made up of R715 to R719 is used to compensate for the differences in the base emitter drops of these input transistors. The output of this differential pair and their collector load resistors R711 and R712 are applied to differential pair Q715 and Q725. Single-ended output appearing at the collector of Q715 of this differential pair is applied to a differential mixer made up of Q730 and Q740. This differential mixer mixes the low frequency signal path and the high frequency signal path. The input circuitry for the high frequency signal path flows through Junction Field Effect Transistor Q720 through capacitor C740 to the other input of the differential mixer Q740. The collector signal Q730 is fed to inverter transistor Q735 so that a complimentary signal of the same phase as the output of

5.7.0 (Continued)

collector Q740 is available for processing in the complimentary emitter follower buffer consisting of Q745 and Q750. Diodes D735 and D740, along with resistor R742, provide the quiescent bias voltages necessary for operation of the complimentary buffer Q745 and Q750. Diodes D745 and D750 provide short circuit protection in the event that the output of this amplifier were accidentally short circuited. The inverting amplifier operates in the same manner as the amplifier previously described and its circuitry is identical with the exception that the feedback components and the input resistors are of different value to provide the necessary gain of one. The output of the inverting amplifier is also fed to a phase selector called the invert relay so that either phase can be fed to the amplitude selector.

5.8.0 FUNCTION CONTROL CIRCUITRY (Refer figure 8.2.7)

Function control circuitry, as shown, consists of four different inputs and their input interface circuitry and the decoding logic necessary to operate the appropriate relays in the generator circuitry. Q610, Q995, Q975 and Q980 are the saturated switches and for a description of their operation refer to Section 5.6.0. The outputs of these saturated switches are fed to the decoding circuitry directly. Integrated circuit Q615D is used to invert the signal from the saturated switch Q610. The output of Q615D is used to drive the parallel combination of the integrated circuits Q620A and Q620D. This output in turn drives the relay K291. The parallel combination of integrated circuits Q615B and Q615C directly drives relay K260. The parallel combination of integrated circuits Q620 and Q620C directly drives relay K290. The logic involved with these three relays is such that the symmetry in the generator loop circuitry can be set for a 50% to 50% ratio or an 85% to 15% ratio. For local control in Model 605, switch decks S610D and S610E control this symmetry on the ramp functions and the pulse functions so that the ratio is 85-15 and all other functions so that the ratio is 50-50. Integrated circuits Q1005A and Q1005D receive their signals from a saturated switch Q995 and from the local control switch deck S610E in the Model 605. The outputs of these integrated circuits are used to directly drive the relays in the generator loop circuitry that create the 90 degree start point in the waveform as compared to the 0 degree start point. Integrated circuits Q1005B and Q1005C are used to provide the operating potentials for relay K677 which provides the offset necessary in the sine shaping network to provide the Haversine waveform, when the generator is programmed for a start level of 90 degrees as compared to the 0 degrees start level. Integrated circuits I015A and I015D receive the outputs of the saturated switch Q975. Integrated circuits Q1015 and Q1015C receive the outputs from saturated switch Q980. These integrated circuits also can receive the signals from the local control switch deck S610A and S610C. The outputs of these integrated circuits are decoded in a manner so as to provide the necessary switching of the relays to connect the sine shaper to the amplifier circuitry or the positive or negative square to the amplifier circuitry or the triangle, etc. Integrated circuit I025A is used to drive relay K695. Integrated circuit I025B is used to drive relay K702. This relay is used to provide offset current in the amplifier circuitry so that the ramp waveform, when processed at 0 degrees start level, can be used as a bipolar signal. Relay K695 is used to apply the output of the sine shaper bridges

5.8.0 (Continued)

to the amplifier circuitry. Integrated circuit Q1030B is used to drive the relay K675 from the outputs of both Q1015C and Q1015B. Relay K675 is used to apply the triangular signal from the integrator to the input of the sine shaping bridges. Integrated circuit Q1030A is used to drive relay K705 when activated from a signal from Q1015A and Q1015C. Relay K705 provides a triangular waveform for processing in the amplifier circuit. Integrated circuit Q1025B and Q1025C are parallel combination used to operate relay K935. Relay K935 supplies the inverting square to the square switching bridge. Integrated circuit Q1020A and Q1020D are parallel combination that operates K936. Relay K936 is used to provide the positive square to the square wave switching bridge. Integrated circuits Q1020B and Q1020C drives relay K937 which is used to apply the output of the square switching bridge to the input of the amplifier circuitry.

5.9.0 FUNCTION AND TRIGGER MODE CIRCUITRY (Refer figure 8.2.8)

The function and trigger mode circuitry, as shown in the schematic diagram, consists of four separate inputs and their saturated switches and necessary decoding logic to decode these signals to drive the phase control, offset control, and trigger mode control. Transistors Q985, Q990, Q630 and Q645 are the saturated switches used to process the incoming signals from the external programming source. The outputs of these saturated switches are used directly as inputs to the integrated circuits used to decode the input signal. Integrated circuit Q1000A and Q1000D are parallel combination used to drive relay K760. They also provide the necessary input for the local control of the Model 605 of the PHASE NORMAL INVERT switch. Integrated circuit Q1000D and Q1000C are parallel combination used to drive relay K761. These two relays are used to provide either one signal from the amplifier circuit to be processed in the amplitude selector or the output of the inverting amplifier to be processed in the amplitude selector. Integrated circuit Q1010B and Q1010C is a parallel combination used to drive relay K700. Integrated circuit Q1010B and C accepts the signal from saturated switch Q990 and from the local control of the Model 605 OFFSET switch. Integrated circuit Q1010A and Q1010D are used to operate relay K755. These two relays provide for selecting the offset signal applied to the amplifier circuitry through fixed bias resistor and also for reducing the gain of the amplifier circuitry by paralleling the feedback resistor of the operational amplifier. Integrated circuit Q635B accepts the signal from saturated switch Q630 or from the TRIGGER mode switch on the front panel of Model 605. The output of this integrated circuit is fed to integrated circuit Q640A and Q640B which operates relay K302. Relay K302 is a continuous run relay on the trigger circuitry. Integrated circuits Q635C and Q635D decode the two inputs and are capable of operating the optional relay K300. This relay is used to provide an inhibit signal to inhibit any trigger from operating the generator when activated. Integrated circuit Q635A accepts the signal from saturated switch Q645 or from the local control TRIGGER mode switch S630B. The output of this integrated circuit is fed to parallel combination of Q640C and Q640D which drives relay K301. Relay K301 is used to provide for either AC or DC coupling of the trigger comparator circuit so that a gated or a triggered mode of operation is available.

5.10.0 OUTPUT AMPLIFIER CIRCUITRY (Refer figure 8.2.9)

Output amplifier circuitry, as shown in the schematic diagram, consists of a wide-band high-performance operational amplifier capable of supplying large amounts of output current. The amplitude selector, as shown, consists of a series of input resistors to this operational amplifier that can be switched on and off providing a control with twelve binary bits. Relays K820 thru K842 operate as switches that can either apply the signal from the phase selector relays directly to the input resistors or leave the circuitry open so that no signal is applied to that resistor. In order that accuracy can be obtained, resistors of the most significant values are provided with an adjustment for gain trimming. Also available as an input to this output amplifier is the analog DC offset programming signal from the rear panel connection. This input is applied to the summing junction of the operational amplifier thru resistor R844. The operational amplifier consists of two signal paths, one covering the frequencies from DC to approximately 100KHz and the other processing the signals from 100KHz and above. These two signals are mixed together in a differential mixer and applied to the output buffers and from there to the decade voltage control circuitry. Dual Junction Field Effect Transistor Q850 accepts the DC to 100KHz input signals and applies them to differential pair Q860 and Q865. The output of this differential pair is taken in a single-ended manner and fed to one input of the differential mixer Q875. The frequencies above 100KHz are applied to the differential mixer through input transistor Q870 which is a high frequency Junction Field Effect Transistor. The output of differential mixer Q875 is fed to the inverter driver Q880. This transistor inverts a signal and increases the power level to a sufficient level to drive the output buffers. The output of Q885 which is one transistor of the differential mixer pair is applied directly to the output buffers. Quiescent operating bias voltages are developed thru the diode resistor combination of D880, D885 and R887. Transistors Q890 thru Q905 form a complimentary buffer circuit with each compliment being a parallel combination of two transistors. These transistors have heat sinks to maintain safe operation at the high power levels involved with the output circuitry of the generator. The feedback resistor from the output to the summing junction is R845 which is paralleled by a compensation capacitor combination C845 and C846. The decade voltage selector consists of a series of relays used to operate 20db pads so that the signal can be attenuated in ratios of 10:1 for each decade of output voltage selection. The parallel combination of R906, R907 and R908 provides the 50 Ω output impedance for the output amplifier circuitry. All attenuator sections in the decade voltage selector provide the output impedance of 50 Ω also. Therefore, it is necessary that the generator circuit also be operated into 50 Ω to maintain amplitude accuracy, waveform quality, etc.

5.11.0 OUTPUT AMPLIFIER CONTROL CIRCUITRY (Refer figure 8.2.10)

The output amplifier control circuitry consists of a series of saturated switches that accept the external input commands and actuate the relays involved with the amplitude selector circuitry. These saturated switches operate in the same manner as previously discussed for input signal conditioning. The extra diode as DI040, DI045, etc., provide for a local control in the Model 605. This allows the switch to directly operate the relay when the saturated switch has been inactivated by the remote inhibit bus.

5.12.0 OUTPUT ATTENUATOR CONTROL CIRCUITRY (Refer figure 8.2.11)

The output attenuator control circuitry consists of two saturated switches for accepting the external input signals. The outputs of these saturated switches are fed to decoding logic so that four different ranges can be accommodated with only two inputs from an external source. The logic circuitry also provides for operation in a local control in the Model 605. Integrated circuits Q955A and B are parallel combination that accepts the input from Q945 and applies it directly to operate relay K916. Integrated circuit Q955C inverts the signal from saturated switch Q945 and applies it directly to integrated circuit Q960A and Q960D whose output is paralleled to operate relay K910. Integrated circuit Q955D is used to invert the signal from saturated switch Q950. The output of saturated switch Q950 is applied directly to the input of integrated circuit Q965B and Q965C. This integrated circuit directly drives relay K915. Q970A and D are paralleled for operation of K921. Q970B and C are also paralleled for operation of K925. Switch deck S955D is used to operate the automatic decimal point indicating lamps 1955 and 1957. These lamps allow the front panel controls to be read directly in output voltage.

SECTION 6

CALIBRATION PROCEDURE

6.1.0 EQUIPMENT REQUIRED

The following test equipment or suitable equivalents of known accuracy are required for complete calibration of the Models 605 and 606 Programmable Waveform Generators.

Adjustable line voltage transformer, Superior Powerstat or equivalent
 Differential or digital voltmeter capable of resolving 1mv and 15V
 Oscilloscope, D.C. through at least 50MHz bandwidth
 Differential plug-in capable of resolving 1mv in 15V
 Frequency and time interval counter
 Distortion analyzer, Hewlett Packard 333A

6.2.0 INITIAL CONTROL SETTINGS

POWER switch	ON
FREQUENCY dials	800Hz
FUNCTION	TRIANGLE
VOLTAGE	8.00V
TRIGGER mode	RUN
PHASE	NORMAL
OFFSET	OFF
DELTA FREQUENCY (Model 605 Only)	CAL

6.3.0 CALIBRATION (Refer figure 6.3.1 and 6.3.2)

After a 30-minute warm-up time, the instrument is prepared for calibration.

1. Connect DVM or Differential Voltmeter to 22V test point (TP 128) and adjust 22V adjust for $22.0V \pm 10mv$.
2. Connect DVM to -22V test point (TP 160) and adjust -22V adjust for $-22.0V \pm 10mv$.
3. Connect DVM to +15V test point (TP 137) and adjust the +15V adjust for $+15.0V \pm 2mv$.
4. Connect DVM to -15V test point (TP 178) and adjust the -15V adjust for $-15.0V \pm 2mv$.
5. CAUTION: The following adjustment is necessary only in cases of extreme mal-adjustment and/or catastrophic failure. The crowbar adjustment requires that the logic power supply +5V be over-voltaged to 5.5V and possible damage to the integrated circuits. Extreme caution must be exercised. To adjust the crowbar, you must adjust the +5V adjust to a voltage of maximum or not greater than 5.5V. Upon achieving this, advance crowbar adjustment until the output waveform from the instrument ceases. This indicates that the 5V power supply is crowbarred and you may now return the 5V adjustment to midscale. Turn instrument power switch OFF and then return to ON again. Instrument output waveform should be restored. It is necessary to readjust the +5V power supply upon completion of this test at any time.

6.3.0 (Continued)

6. Connect DVM to TP117 and adjust the +5V adjust for $5.0V \pm 10mv$.
7. Using adjustable line transformer, vary line voltage between 105V and 125V AC and probe each power supply in turn, checking regulation. $\pm 22V$ supplies should regulate within 20mv. $\pm 15V$ supplies should regulate within 2mv. +5V supply should regulate within 10mv.
8. Connect oscilloscope with differential plug-in to integrator output TP386. Monitor comparison voltage on the differential plug-in with Digital Voltmeter so that accuracy can be maintained to within 1mv. Adjust positive peak adjust for positive triangle peak of $5.00V \pm 2mv$. Adjust negative peak adjust for negative peak of triangle to be $5.00V \pm 2mv$.
9. Using DVM on most sensitive range, probe test point LSB. Adjust LSB balance adjust for $0V \pm .1mv$. NOTE: Use TP243 as ground point during these measurements.
10. Reset frequency dial to 000.Hz and connect DVM to test point MSB. Adjust MSB balance adjustment for $0.00V \pm .1mv$.
11. Connect DVM to rear side of R267 and adjust VCF balance control for a voltage reading of $0.00 \pm .2mv$.
12. Readjust frequency for a reading of 001Hz and note DVM reading as connected in previous adjustment. Connect DVM across R251 and adjust minus drive balance for the same voltage reading as obtained in the noted adjustment. Connect DVM across R270 and adjust plus drive balance adjust for same voltage reading as obtained in previous test.
13. Reprogram generator for frequency to 00XHz. Take reading across R270. Connect DVM across R276 and adjust positive current balance for new reading. Connect DVM across the combination of R256 and potentiometer R257. Adjust the negative current balance adjust for the same reading obtained in the positive current balance adjust.
14. Program generator for a positive pulse output. Connect frequency counter to the generator output and adjust the time interval of the output pulse by manipulating the generator frequency controls until a reading of 150.0 μs is achieved. Switch counter from reading time interval to reading period of the pulse and adjust ramp time adjust for a reading of 1000 μs .
15. Program generator for a positive square output and set counter to read time interval. Adjust the symmetry adjust until time symmetry can be obtained by reading both time intervals of the square signal.
16. Program generator for an 80.0KHz squarewave output signal. Connect counter to squarewave and read frequency. Adjust the 80F adjustment for 80.0KHz output

6.3.0 (Continued)

- signal. Reprogram generator for 40.0KHz and adjust the 40F adjustment for 40.0KHz. Reprogram generator for 20.0KHz and adjust the 20F adjust for a 20.0KHz signal. Reprogram generator for 10.0KHz and adjust the 10F adjust for 10.0KHz signal. Reprogram generator for 08.0 KHz and adjust the 8F adjust for 8KHz output signal. Reprogram generator for 04.0KHz and adjust the 4F adjust for 4KHz output signal.
17. Reprogram generator for an 100KHz squarewave and adjust 80KHz adjustment for 100KHz. Reprogram generator for a 800KHz squarewave and adjust the H.F. Comp. adjust for 800KHz.
 18. Reprogram generator for an 80.0KHz squarewave and readjust the 80F adjust for 80.0KHz. Readjust the 8F adjust for 8.0KHz.
 19. Repeat steps 16 through 18 until a satisfactory adjustment has been achieved.
 20. Reprogram generator for a frequency of 10.00KHz. Adjust the 10KHz adjust for 10.00KHz. Reprogram generator for 1000Hz. Adjust the 1000Hz adjust for 1000Hz. Reprogram generator for 100.0Hz. Adjust the 100Hz adjust for 100.0Hz. Reprogram generator for 10.00Hz and adjust the 10Hz adjust for 10.00Hz.
 21. Reprogram generator for a frequency of 1000mHz. Adjust 1000mHz timing adjust for 1000mHz.
 22. Adjust 10mHz symmetry adjust for a time symmetry.
 23. Repeat steps 20 through 21 as needed.
 24. With generator operating at 1000mHz, switch CAL NORM switch to CAL and record frequency. Reprogram generator with Range SW for a frequency of 100.0mHz and adjust 100.0mHz timing adjust for a frequency one decade lower than obtained in the CAL position at 1000mHz. Reprogram generator with Range SW for a frequency of 10.00mHz and adjust frequency for one decade lower than obtained in previous tests. Return CAL NORM switch to NORMAL.
 25. Program generator for a 1000Hz triangle and monitor the output of the amplifier at R75I. Adjust the balance adjust for triangle peaks to be within 2MV absolute value one another.
 26. Program generator for sinewave output. Connect distortion analyzer to output and adjust sine input adjust for minimum sine distortion. Readjust distortion adjust 1, 2, 3, and 4 for minimum distortion. Interaction between adjustments may necessitate readjusting certain adjustments.
 27. Program generator for an output voltage of 0.00V and adjust output amplitude balance for $0V \pm 5MV$.

6.3.0 (Continued)

28. Reprogram generator for an output voltage of 8.00V sinewave. Adjust sine peaks A and B along with the gain adjust control for an output sinewave of 8V P-P $\pm 2\text{MV}$. Sine peak A and sine peak B adjustments are used to control the DC component.
29. Reprogram generator for a triangular wave output signal and adjust triangle amplitude adjust for triangle output amplitude of 8.00V P-P $\pm 5\text{MV}$.
30. Reprogram generator for a positive square output and adjust the + square adjust and - square adjust for an output amplitude of 8.00V P-P $\pm 10\text{MV}$.
31. Program generator for Offset function. Adjust Offset adjust for the negative peak value to be 0V $\pm 10\text{MV}$ and adjust the Gain/2 adjust for the positive peak to be 4.0V $\pm 10\text{MV}$.
32. Program generator for an inverted phase output signal. Adjust the inverting gain adjust and the inverting balance adjust for 8V P-P $\pm 10\text{MV}$.
33. Program generator for an output voltage of 4.00V P-P and adjust the 40 adjust for 4.00V. Program generator for 2.00V output signal. Adjust 20 adjust for 2V. Program generator for 1.00V output level. Adjust 10 adjust for 1.00V. Program generator for .8V P-P output level. Adjust 8 adjust for .8V P-P. Program generator for .4V P-P. Adjust 4 adjust for .4V P-P output level.
34. Program generator for a ramp function at 8V P-P. Switch trigger mode to Gate. adjust the Ramp Offset Adjust so that the start level is at -4.00V $\pm 10\text{MV}$.
35. Reprogram for free running ramp and adjust L.O. Offset adjust for the negative peak of the ramp to be -4.00V $\pm 10\text{MV}$.
36. Reprogram generator for a Haversine waveform and adjust the Sine Offset adjust for minimum distortion.
37. Reprogram generator for ramp output in Gate mode and adjust the Ramp L.O. adjust for -4.00V $\pm 10\text{MV}$ at the output.
38. Reprogram for triangle output in the Gate mode and adjust the Triangle L.O. adjust for 0V $\pm 10\text{MV}$.
39. Reprogram frequency multiplier for 010.Hz and adjust the X100 L.O. Balance for 0V $\pm 10\text{MV}$.
40. Reprogram generator for 999KHz squarewave and probe the amplifier at R751 and adjust the Comp adjust for minimum ringing and overshoot.
41. Probe the Inverting Amplifier at R811 and adjust the Inv Comp adjust for minimum ringing and overshoot.

6.3.0 (Continued)

42. Monitor output waveform and adjust the Output Comp adjust for minimum overshoot and ringing while also checking for minimum deviation of sine wave output amplitude.

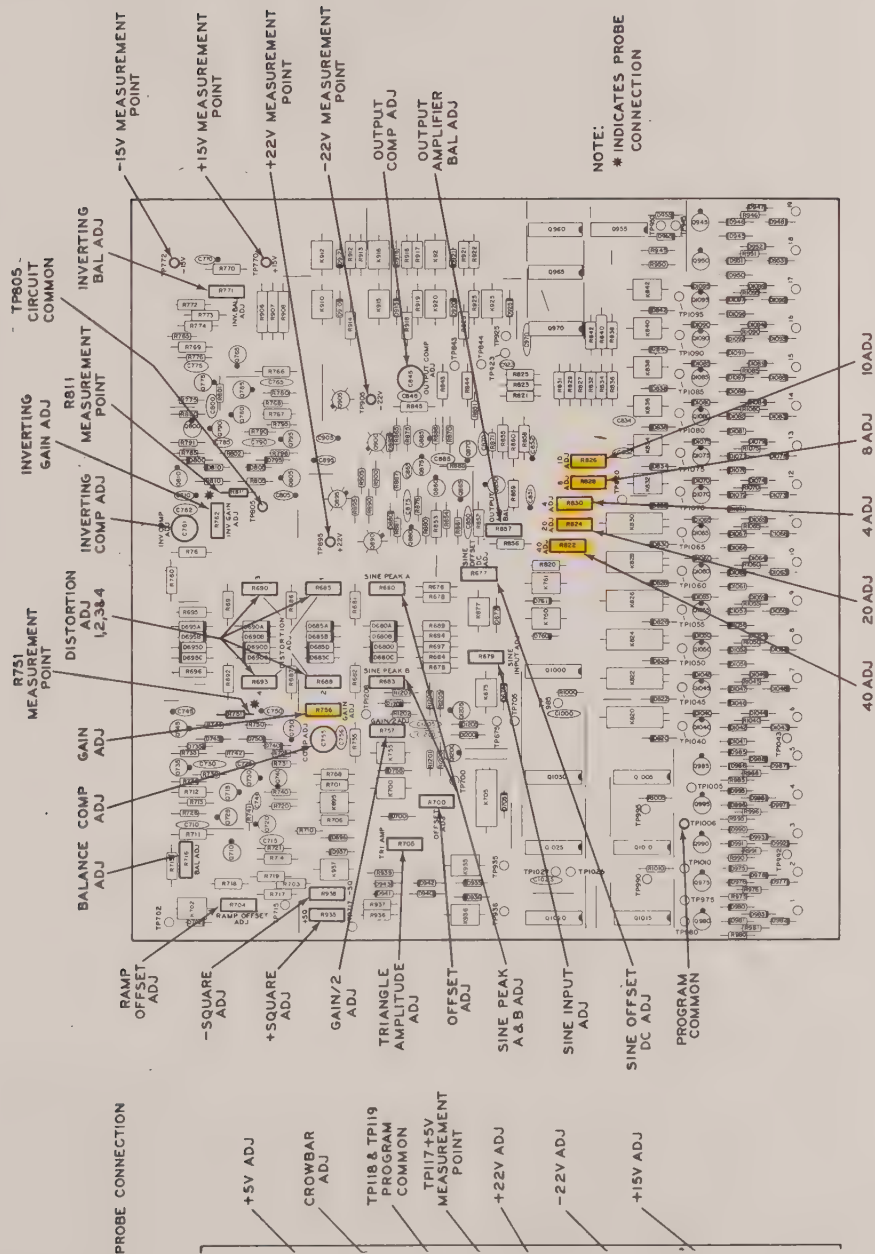


FIGURE 6.3.2 ADJUSTMENT LOCATION DETAIL

SECTION 7

PARTS LIST

CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
00000	U.S.A. Cannon	Any supplier of U.S.	870	Meats, Inc.	Palo Alto, Calif.	3293	Hagen Products Div. of	Newport Beach, Calif.	81740	Eveready Battery	New York, N.Y.
00048	McQuay Electronics	Mount Holly Springs, Pa.	17336	Philadelpha Handle Co.	Cumby, N.J.	32977	Hughes Aircraft Co.	Los Angeles, Calif.	83777	Amel Eng. and Mfg., Inc.	Huntington, Ind.
00073	Sage Electronics Corp.	Bochester, N.Y.	12697	Clorox Mfg. Co.	Dover, N.H.	33445	Amperex Electronic Co., Inc.	Hicksville, N.Y.	83821	Loyd Scruggs Co.	Fresh, Mass.
00034	Mumford Co.	Calton, Calif.	2859	Nippon Elect. Co., Ltd.	Tokyo, Japan		Div. No. American		84171	Arco Electronics, Inc.	New York, N.Y.
00035	Wavite Corp.	New York, N.Y.	12730	Newton Electric Corp.	Newport Beach, Calif.		Philips Co., Inc.		84286	A.J. Glanville Co., Inc.	San Francisco, Calif.
00073	Garlock Packing Co.	Camden, N.J.	13003	Thermoly	Irwin, Texas	37490	Beckman-Holger Corp.	S. Pasadena, Calif.	8441	Good All Electric Mfg. Co.	Ogallala, Neb.
00056	Electronic Prod. Div.	New Bedford, Mass.	13396	Telatron (G.M.B.H.)	Mannheim, Germany	35506	Bradley Semiconductor Corp.	Hamden, Conn.	84770	Sarkis Tarsan, Inc.	Tombington, Ind.
00179	Am. Inc.	Hanbury, Pa.	3835	Midland Mfg. Co.	Kansas City, Kansas	35559	Carling Electric, Inc.	Harford, Conn.	85414	Bauman Manufacturing Co.	Boonton, N.J.
00081	Ancora Radio Corp.	Boonton, N.J.	44999	Sem-Tech	Newbury Park, Calif.	35682	George K. Garrett Co., Inc.	Chicago, Ill.	85474	R.M. Bracombe and Co.	San Francisco, Calif.
00091	Northern Eng. Labs. Inc.	Burlington, Wis.	44993	Cal. Relator Corp.	Santa Monica, Calif.	37374	Federal Screw Prod. Co.	Chicago, Illinois	85600	Kalied Kards, Inc.	New Haven, Conn.
00095	Sungma Electric Co.	Marion, Illinois	44998	American Component Inc.	Cincinnati, Ohio	37375	Fischer Special Mfg. Co.	Cincinnati, Ohio	85601	Seamless Rubber Co.	Chicago, Illinois
00086	Orill Inc. (Caga)	Los Angeles, Calif.	4655	Conell Dabiller E. Corp.	So. Plainfield, N.J.	37393	The General Industries Co.	Elizria, Ohio	86197	Clifton Precision Products	Clifton Heights, Pa.
00091	Carl E. Hulmer Corp.	Los Angeles, Calif.	4655	Williams Mfg. Co.	San Jose, Calif.	37396	Golden Strapping and Tool	Oakland, Ind.	86199	Precision Rubber Products Corp.	Dayton, Ohio
00121	Allen Bradley Co.	Milwaukee, Wis.	15703	Webster Electric Co., Inc.	N. Hollywood, Calif.	37397	JFD Electronics Corp.	Brooklyn, N.Y.	86684	Radio Corp. of America, RCA	Harrison, N.J.
00125	TEW Semiconductors Inc.	Beavertown, Calif.	15707	Adjustable Building Co.	Santa Clara, Calif.	37405	Jenning Radio Mfg. Co.	San Jose, Calif.		Electron Tube Div.	
00128	Liton Industries, Inc.	Longwood, Calif.	15909	Twentieth Century	Cal Spring, Tex.	37408	Sigalizer, Inc.	Weybridge, Mass.	87216	Philco Corp. (Lansing Div.)	Lansing, Pa.
00195	Telex Instruments, Inc.	Dallas, Texas	16037	Cal Spring Co.	The Doren Co.	14455	J. H. Wilson and Sons	Chicago, Illinois	87473	Western Fiberglass Div.	San Francisco
00149	The Alliance Mfg. Co.	Transistor Prod. Div.	16352	Service Pine Mica Co.	Spruce Pine, N.C.	14458	R.F. Prod. Div. of Amphelph	Danbury, Conn.			
00161	Chast-Tek Corp.	Indianapolis, Ind.	16588	Computer Diode Corp.	Lodi, N.J.	14970	E.F. Johnson Co.	Waco, Minn.	87900	Tuwer Mfg. Co.	Providence, R.I.
00199	Amesick Corp.	Rockford, Ill.	16588	DeLo Radio, Division of	Kokomo, Ind.	15042	International Resistance Co.	Philadelphia, Pa.	88140	Cul-Exammer, Inc.	Lincoln, Illinois
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	G.M. Corp.	Cunago Park, Calif.	15173	James Howard B., Div. of	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Amesick Corp.	Rockford, Ill.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
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00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238	Kulka Electric Corp.	Chicago, Illinois	88698	Goval-National Batteries, Inc.	St. Paul, Minn.
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00199	Pacific Relay, Inc.	Van Nuys, Calif.	17009	Thermostat, Inc.	Mountain View, Calif.	15238					

SECTION 7

PARTS LIST

PART	DESCRIPTION	EXACT NO	PFC	PART	DESCRIPTION	EXACT NO	PFC
C0010	CAPACITOR, 5 MFD 150 VOLT	2900016	56289	C1200	CAPACITOR, 0.05 UF DISC	2930010	9141F
C0100	CAPACITOR, 0.05 UF DISC	2930010	9141F	C1205	CAPACITOR, 0.05 UF DISC	2930010	9141F
C0101	CAPACITOR, 6500MFD 15V	2900049	853	C1206	DIODE, 1N4005	1524001	4713
C0102	CAPACITOR, 1000 PF DISC	2930000	9141E	C1207	DIODE, 1N4005	1524005	4713
C0103	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1208	DIODE, 1N4005	1524005	4713
C0105	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1209	DIODE, 1N4005	1524005	4713
C0120	CAPACITOR, 2500MFD 35V	2900034	853	C1210	DIODE, 1N4719	1524011	1295
C0121	CAPACITOR, 4700F MICA	2910539	853	C1215	DIODE, 1N4001	1524011	1295
C0125	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1216	DIODE, 1N4719	1524011	1295
C0130	CAPACITOR, 4700F MICA	2910539	853	C1217	RECTIFIER BRIDGE, ADAP2CA-3	1524011	1295
C0135	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1218	DIODE, 1N4001	1524011	1295
C0140	CAPACITOR, 2500MFD 35V	2900034	853	C1219	DIODE, 1N4001	1524011	1295
C0141	CAPACITOR, 2700F MICA	2910540	853	C1220	DIODE, 1N4001	1524011	1295
C0155	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1221	DIODE, 1N4001	1524011	1295
C0160	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1222	DIODE, 1N4001	1524011	1295
C0165	CAPACITOR, 5000 PF DISC	2930011	9141E	C1223	DIODE, 1N4001	1524011	1295
C0166	CAPACITOR, 2200F MICA	2910555	853	C1224	DIODE, 1N4001	1524011	1295
C0175	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1225	DIODE, 1N4001	1524011	1295
C0176	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1226	DIODE, 1N4001	1524011	1295
C0205	CAPACITOR, 2200F MICA	2910555	853	C1227	DIODE, 1N4001	1524011	1295
C0206	CAPACITOR, 5000 PF DISC	2930011	9141E	C1228	DIODE, 1N4001	1524011	1295
C0207	CAPACITOR, 2700F MICA	2910540	853	C1229	DIODE, 1N4001	1524011	1295
C0210	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1230	DIODE, 1N4001	1524011	1295
C0215	CAPACITOR, 2200F MICA	2910555	853	C1231	DIODE, 1N4001	1524011	1295
C0216	CAPACITOR, 5000 PF DISC	2930011	9141E	C1232	DIODE, 1N4001	1524011	1295
C0217	CAPACITOR, 2700F MICA	2910540	853	C1233	DIODE, 1N4001	1524011	1295
C0220	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1234	DIODE, 1N4001	1524011	1295
C0230	CAPACITOR, 2200F MICA	2910555	853	C1235	DIODE, 1N4001	1524011	1295
C0231	CAPACITOR, 5000 PF DISC	2930011	9141E	C1236	DIODE, 1N4001	1524011	1295
C0235	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1237	DIODE, 1N4001	1524011	1295
C0245	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1238	DIODE, 1N4001	1524011	1295
C0255	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1239	DIODE, 1N4001	1524011	1295
C0265	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1240	DIODE, 1N4001	1524011	1295
C0275	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1241	DIODE, 1N4001	1524011	1295
C0285	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1242	DIODE, 1N4001	1524011	1295
C0300	CAPACITOR, 100F MICA	2910529	853	C1243	DIODE, 1N4001	1524011	1295
C0301	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1244	DIODE, 1N4001	1524011	1295
C0302	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1245	DIODE, 1N4001	1524011	1295
C0303	CAPACITOR, 2200F MICA	2910555	853	C1246	DIODE, 1N4001	1524011	1295
C0304	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1247	DIODE, 1N4001	1524011	1295
C0304	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1248	DIODE, 1N4001	1524011	1295
C0305	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1249	DIODE, 1N4001	1524011	1295
C0310	CAPACITOR, 100F MICA	2910537	853	C1250	DIODE, 1N4001	1524011	1295
C0330	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1251	DIODE, 1N4001	1524011	1295
C0340	CAPACITOR, 100F MICA	2910537	853	C1252	DIODE, 1N4001	1524011	1295
C0341	CAPACITOR, 0.01 UF DISC	2930005	9141E	C1253	DIODE, 1N4001	1524011	1295
C0350	CAPACITOR, 5PF MICA	2910501	853	C1254	DIODE, 1N4001	1524011	1295
C0360	CAPACITOR, 1000 PF DISC	2930000	9141E	C1255	DIODE, 1N4001	1524011	1295
C0365	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1256	DIODE, 1N4001	1524011	1295
C0370	CAPACITOR, 5000 PF DISC	2930011	9141E	C1257	DIODE, 1N4001	1524011	1295
C0371	CAPACITOR, 100F MICA	2910529	853	C1258	DIODE, 1N4001	1524011	1295
C0380	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1259	DIODE, 1N4001	1524011	1295
C0381	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1260	DIODE, 1N4001	1524011	1295
C0385	CAPACITOR, 68PF MICA	2910523	853	C1261	DIODE, 1N4001	1524011	1295
C0386	CAPACITOR, 5.5-18PF TRIM	2910011	72982	C1262	DIODE, 1N4001	1524011	1295
C0390	CAPACITOR, 18PF MICA	2910552	14655	C1263	DIODE, 1N4001	1524011	1295
C0401	CAPACITOR, 68PF MICA	2910523	853	C1264	DIODE, 1N4001	1524011	1295
C0402	CAPACITOR, 3PF MICA	2910500	853	C1265	DIODE, 1N4001	1524011	1295
C0405	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1266	DIODE, 1N4001	1524011	1295
C0410	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1267	DIODE, 1N4001	1524011	1295
C0420	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1268	DIODE, 1N4001	1524011	1295
C0421	CAPACITOR, 22PF MICA	2910530	853	C1269	DIODE, 1N4001	1524011	1295
C0425	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1270	DIODE, 1N4001	1524011	1295
C0426	CAPACITOR, 47PF MICA	2910532	853	C1271	DIODE, 1N4001	1524011	1295
C0435	CAPACITOR, TIMING SET	2950004	10597	C1272	DIODE, 1N4001	1524011	1295
C0436	CAPACITOR, 5.5-18PF TRIM	2910011	72982	C1273	DIODE, 1N4001	1524011	1295
C0437	CAPACITOR, 82PF MICA	2910533	853	C1274	DIODE, 1N4001	1524011	1295
C0438	CAPACITOR, 10PF MICA	2910529	853	C1275	DIODE, 1N4001	1524011	1295
C0565	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1276	DIODE, 1N4001	1524011	1295
C0580	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1277	DIODE, 1N4001	1524011	1295
C0615	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1278	DIODE, 1N4001	1524011	1295
C0635	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1279	DIODE, 1N4001	1524011	1295
C0710	CAPACITOR, 0.05 UF DISC	2930005	9141E	C1280	DIODE, 1N4001	1524011	1295
C0715	CAPACITOR, 2200F MICA	2910555	853	C1281	DIODE, 1N4001	1524011	1295
C0725	CAPACITOR, 1000 PF DISC	2930000	9141E	C1282	DIODE, 1N4001	1524011	1295
C0730	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1283	DIODE, 1N4001	1524011	1295
C0735	CAPACITOR, 10PF MICA	2910529	853	C1284	DIODE, 1N4001	1524011	1295
C0740	CAPACITOR, 5000 PF DISC	2930011	9141E	C1285	DIODE, 1N4001	1524011	1295
C0745	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1286	DIODE, 1N4001	1524011	1295
C0750	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1287	DIODE, 1N4001	1524011	1295
C0755	CAPACITOR, 5.5-18PF TRIM	2910011	72982	C1288	DIODE, 1N4001	1524011	1295
C0756	CAPACITOR, 5PF MICA	2910501	853	C1289	DIODE, 1N4001	1524011	1295
C0761	CAPACITOR, 5.5-18PF TRIM	2910011	72982	C1290	DIODE, 1N4001	1524011	1295
C0762	CAPACITOR, 5PF MICA	2910501	853	C1291	DIODE, 1N4001	1524011	1295
C0765	CAPACITOR, 0.01 UF DISC	2930005	9141E	C1292	DIODE, 1N4001	1524011	1295
C0770	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1293	DIODE, 1N4001	1524011	1295
C0775	CAPACITOR, 2200F MICA	2910555	853	C1294	DIODE, 1N4001	1524011	1295
C0785	CAPACITOR, 1000 PF DISC	2930000	9141E	C1295	DIODE, 1N4001	1524011	1295
C0790	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1296	DIODE, 1N4001	1524011	1295
C0796	CAPACITOR, 10PF MICA	2910529	853	C1297	DIODE, 1N4001	1524011	1295
C0800	CAPACITOR, 5000 PF DISC	2930011	9141E	C1298	DIODE, 1N4001	1524011	1295
C0805	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1299	DIODE, 1N4001	1524011	1295
C0810	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1300	DIODE, 1N4001	1524011	1295
C0832	CAPACITOR, 5PF MICA	2910501	853	C1301	DIODE, 1N4001	1524011	1295
C0834	CAPACITOR, 5PF MICA	2910501	853	C1302	DIODE, 1N4001	1524011	1295
C0845	CAPACITOR, 5.5-18PF TRIM	2910011	72982	C1303	DIODE, 1N4001	1524011	1295
C0846	CAPACITOR, 5PF MICA	2910501	853	C1304	DIODE, 1N4001	1524011	1295
C0850	CAPACITOR, 0.01 UF DISC	2930005	9141E	C1305	DIODE, 1N4001	1524011	1295
C0851	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1306	DIODE, 1N4001	1524011	1295
C0852	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1307	DIODE, 1N4001	1524011	1295
C0865	CAPACITOR, 1000 PF DISC	2930000	9141E	C1308	DIODE, 1N4001	1524011	1295
C0870	CAPACITOR, 2200F MICA	2910555	853	C1309	DIODE, 1N4001	1524011	1295
C0875	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1310	DIODE, 1N4001	1524011	1295
C0885	CAPACITOR, 5000 PF DISC	2930011	9141E	C1311	DIODE, 1N4001	1524011	1295
C0886	CAPACITOR, 10PF MICA	2910529	853	C1312	DIODE, 1N4001	1524011	1295
C0895	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1313	DIODE, 1N4001	1524011	1295
C0905	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002	C1314	DIODE, 1N4001	1524011	1295
C0923	CAPACITOR, 5000 PF DISC	2930011	9141E	C1315	DIODE, 1N4001	1524011	1295
C0925	CAPACITOR, 2700F MICA	2910540	853	C1316	DIODE, 1N4001	1524011	1295
C0970	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1317	DIODE, 1N4001	1524011	1295
C1000	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1318	DIODE, 1N4001	1524011	1295
C1025	CAPACITOR, 0.05 UF DISC	2930010	9141E	C1319	DIODE, 1N4001	1524011	1295

PARTS LIST

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SECTION 7

PARTS LIST

PART	DESCRIPTION	EXACT NO	MFC	PART	DESCRIPTION	EXACT NO	MFC
C0780	TRANSISTOR, 2N4250	1564250.	7263.	R0208	RESISTOR, 2210 OHM 1/4w 1% METAL FILM	3132211.	7115.
C0785	TRANSISTOR, 2N4250	1564250.	7263.	R0209	RESISTOR, 2150 OHM 1/4w 1% METAL FILM	3132151.	7115.
C0790	TRANSISTOR, MPS543	156543.	4713.	R0210	POTENTIOMETER, 500 OHM PC TRIM	3110090.	80294.
C0795	TRANSISTOR, 2N4121	1564121.	7263.	R0211	RESISTOR, 1500 OHM 1/4w 1% METAL FILM	3070152.	7115.
C0800	TRANSISTOR, T1587	1560067.	1295.	R0212	RESISTOR, 4900 OHM 1/4w 1% METAL FILM	3134901.	7115.
C0805	TRANSISTOR, T1587	1560067.	1295.	R0213	RESISTOR, 15000K OHM 1/4w 5% CARBON	3070156.	7115.
C0810	TRANSISTOR, 2N4121	1564121.	7263.	R0214	POTENTIOMETER, 10K OHM WITH SWI	3110333.	71450.
C0820	TRANSISTOR, UC2138	1562138.	41637.	R0215	POTENTIOMETER, 20K OHM PC TRIM	3110131.	76488.
C0860	TRANSISTOR, 2N4250	1564250.	7263.	R0216	RESISTOR, 100K OHM 1/4w 1% METAL FILM	3110003.	7115.
C0865	TRANSISTOR, 2N4250	1564250.	7263.	R0217	RESISTOR, 100 OHM 1/4w 1% METAL FILM	3131000.	7115.
C0870	TRANSISTOR, 2N5245	1565245.	1295.	R0218	RESISTOR, 2210 OHM 1/4w 1% METAL FILM	3132211.	7115.
C0875	TRANSISTOR, MPS543	156543.	4713.	R0219	RESISTOR, 2150 OHM 1/4w 1% METAL FILM	3132151.	7115.
C0880	TRANSISTOR, 2N4121	1564121.	7263.	R0220	POTENTIOMETER, 500 OHM TRIM	3110142.	71450.
C0885	TRANSISTOR, T1587	1560067.	1295.	R0221	RESISTOR, 1500 OHM 1/4w 5% CARBON	3070152.	7115.
C0890	TRANSISTOR, 2N2219	1562219.	1295.	R0222	RESISTOR, 49.9K OHM 1/4w 1% METAL FILM	3134992.	7115.
C0895	TRANSISTOR, 2N2219	1562219.	1295.	R0223	RESISTOR, 4900 OHM 1/4w 1% METAL FILM	3134991.	7115.
C0900	TRANSISTOR, 2N2905	1562905.	1295.	R0224	RESISTOR, 4900 OHM 1/4w 1% METAL FILM	3134991.	7115.
C0905	TRANSISTOR, 2N2905	1562905.	1295.	R0225	RESISTOR, 51 OHM 1/4w 5% CARBON	3070510.	7115.
C0945	TRANSISTOR, 2N5223	1565223.	4713.	R0226	RESISTOR, 51 OHM 1/4w 5% CARBON	3070510.	7115.
C0950	TRANSISTOR, 2N5223	1565223.	4713.	R0227	POTENTIOMETER, 20K OHM PC TRIM	3110131.	76488.
C0955	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0231	RESISTOR, 100K OHM 1/4w 1% METAL FILM	3131003.	7115.
C0960	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0232	RESISTOR, 2370 OHM 1/4w 1% METAL FILM	3132371.	7115.
C0965	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0233	RESISTOR, 100 OHM 1/4w 1% METAL FILM	3131000.	7115.
C0970	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0234	RESISTOR, 4900 OHM 1/4w 1% METAL FILM	3134991.	7115.
C0975	TRANSISTOR, 2N5223	1565223.	4713.	R0235	RESISTOR, 1500 OHM 1/4w 5% CARBON	3070152.	7115.
C0980	TRANSISTOR, 2N5223	1565223.	4713.	R0236	RESISTOR, 100K OHM 1/4w 1% METAL FILM	3131003.	7115.
C0985	TRANSISTOR, 2N5223	1565223.	4713.	R0240	POTENTIOMETER, 20K OHM PC TRIM	3110131.	76488.
C0990	TRANSISTOR, 2N5223	1565223.	4713.	R0241	POTENTIOMETER, 20K OHM PC TRIM	3110131.	76488.
C0995	TRANSISTOR, 2N5223	1565223.	4713.	R0242	POTENTIOMETER, 20K OHM PC TRIM	3110131.	76488.
C1000	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0243	POTENTIOMETER, 20K OHM PC TRIM	3110131.	76488.
C1005	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0245	POTENTIOMETER, 10K OHM TRIM	3110150.	71450.
C1010	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0250	RESISTOR, 2000 OHM 1/4w 1% METAL FILM	3132001.	7115.
C1015	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0251	RESISTOR, 2000 OHM 1/4w 1% METAL FILM	3132001.	7115.
C1020	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0255	POTENTIOMETER, 10K OHM TRIM	3110150.	71450.
C1025	INTEGRATED CIRCUIT, SN7400N	1580011.	1295.	R0256	RESISTOR, 3320 OHM 1/4w 1% METAL FILM	3133321.	7115.
C1030	INTEGRATED CIRCUIT, SN7400N	1580026.	1295.	R0257	POTENTIOMETER, 250 OHM	3110145.	71450.
C1040	TO			R0260	RESISTOR, 4750 OHM 1/4w 1% METAL FILM	3134751.	7115.
C1065	TRANSISTOR, 2N3643	1563643.	4713.	R0261	POTENTIOMETER, 250 OHM	3110145.	71450.
C1070	TO			R0265	POTENTIOMETER, 10K OHM TRIM	3110150.	71450.
C1095	TRANSISTOR, 2N5223	1565223.	4713.	R0266	RESISTOR, 100 OHM 1/4w 1% METAL FILM	3131000.	7115.
C1200	TRANSISTOR, EN2464	1562464.	7263.	R0267	RESISTOR, 100K OHM 1/4w 1% METAL FILM	3131001.	7115.
C1205	TRANSISTOR, 2N4250	1564250.	7263.	R0270	RESISTOR, 1000 OHM 1/4w 1% METAL FILM	3131001.	7115.
R0010	RESISTOR, 51K OHM 1/2w 5% CARBON	3010513.	1121.	R0275	POTENTIOMETER, 10K OHM TRIM	3110150.	71450.
R0011	RESISTOR, 33K OHM 1/2w 5% CARBON	3010333.	1121.	R0276	RESISTOR, 1000 OHM 1/4w 1% METAL FILM	3131001.	7115.
R0012	RESISTOR, 33K OHM 1/4w 5% CARBON	3070333.	1121.	R0280	RESISTOR, 1050 OHM 1/4w 1% METAL FILM	3131051.	7115.
R0013	RESISTOR, 33K OHM 1/4w 5% CARBON	3070333.	1121.	R0281	RESISTOR, 1000 OHM 1/4w 5% CARBON	3070102.	7115.
R0014	RESISTOR, 750 OHM 1/4w 1% METAL FILM	3117500.	7115.	R0285	POTENTIOMETER, 10K OHM TRIM	3110150.	71450.
R0101	POTENTIOMETER, 500 OHM TRIM	3110142.	71450.	R0290	RESISTOR, 1600 OHM 1/4w 1% METAL FILM	3131601.	7115.
R0102	RESISTOR, 2210 OHM 1/4w 1% METAL FILM	3132211.	7115.	R0291	POTENTIOMETER, 10K OHM TRIM	3110141.	71450.
R0103	RESISTOR, 56 OHM 1/4w 5% CARBON	3070560.	1121.	R0292	POTENTIOMETER, 2.5K OHM TRIM	3110148.	71450.
R0105	RESISTOR, 0.56 OHM 2W WIREWOUND	3080005.	75042.	R0293	RESISTOR, 499 OHM 1/4w 1% METAL FILM	3134990.	7115.
R0110	RESISTOR, 300 OHM 1/4w 5% CARBON	3070301.	1121.	R0300	RESISTOR, 10K OHM 1/2w 5% CARBON	3010103.	7115.
R0111	RESISTOR, 1910 OHM 1/4w 1% METAL FILM	3131911.	7115.	R0301	RESISTOR, 150K OHM 1/4w 5% CARBON	3070154.	7115.
R0112	POTENTIOMETER, 500 OHM TRIM	3110142.	71450.	R0302	RESISTOR, 10K OHM 1/4w 5% CARBON	3070103.	7115.
R0113	RESISTOR, 5.0 OHM THERMISTOR	3170050.	1295.	R0303	RESISTOR, 82K OHM 1/4w 5% CARBON	3070823.	7115.
R0114	RESISTOR, 5000 OHM THERMISTOR	3175001.	1295.	R0304	RESISTOR, 56K OHM 1/4w 5% CARBON	3070563.	7115.
R0115	RESISTOR, 120 OHM 1/4w 5% CARBON	3070121.	1121.	R0305	RESISTOR, 4700 OHM 1/4w 5% CARBON	3070472.	7115.
R0116	RESISTOR, 1600 OHM 1/4w 5% CARBON	3070162.	1121.	R0306	RESISTOR, 2700 OHM 1/4w 5% CARBON	3070272.	7115.
R0117	RESISTOR, 68K OHM 1W 10% CARBON	3060683.	1121.	R0307	RESISTOR, 1000 OHM 1/4w 5% CARBON	3070102.	7115.
R0120	RESISTOR, 2200 OHM 1/4w 5% CARBON	3070222.	1121.	R0308	RESISTOR, 100 OHM 1/2w 5% CARBON	3010101.	7115.
R0125	RESISTOR, 1.0 OHM 1/2w 5% CARBON	3010010.	1121.	R0310	RESISTOR, 2200 OHM 1/4w 5% CARBON	3070222.	7115.
R0126	RESISTOR, 7500 OHM 1/4w 1% METAL FILM	3137501.	7115.	R0311	RESISTOR, 1500 OHM 1/4w 5% CARBON	3070152.	7115.
R0127	POTENTIOMETER, 1K OHM TRIM	3110147.	71450.	R0312	RESISTOR, 1500 OHM 1/4w 5% CARBON	3070152.	7115.
R0128	RESISTOR, 3010 OHM 1/4w 1% METAL FILM	3133011.	7115.	R0313	RESISTOR, 1500 OHM 1/4w 5% CARBON	3070132.	7115.
R0130	RESISTOR, 1600 OHM 1/4w 5% CARBON	3070162.	1121.	R0314	RESISTOR, 1300 OHM 1/4w 5% CARBON	3070130.	7115.
R0135	RESISTOR, 2.0 OHM 1/2w 5% CARBON	3010020.	1121.	R0315	RESISTOR, 1200 OHM 1/4w 5% CARBON	3070122.	7115.
R0136	RESISTOR, 3320 OHM 1/4w 1% METAL FILM	3133321.	7115.	R0316	RESISTOR, 5600 OHM 1/4w 5% CARBON	3070562.	7115.
R0137	POTENTIOMETER, 1K OHM SUB-IN	3110136.	80294.	R0317	RESISTOR, 1600 OHM 1/4w 5% CARBON	3070182.	7115.
R0138	RESISTOR, 3010 OHM 1/4w 1% METAL FILM	3133011.	7115.	R0318	RESISTOR, 1000 OHM 1/4w 5% CARBON	3070102.	7115.
R0139	RESISTOR, SELECTED VALU			R0321	RESISTOR, 5600 OHM 1/4w 5% CARBON	3070562.	7115.
R0140	RESISTOR, 1600 OHM 1/4w 5% CARBON	3070162.	1121.	R0322	RESISTOR, 2000 OHM 1/4w 5% CARBON	3070202.	7115.
R0141	RESISTOR, 18K OHM 1/4w 5% CARBON	3070183.	1121.	R0325	POTENTIOMETER, 100 OHM TRIM	3110141.	71450.
R0142	RESISTOR, 100 OHM 1/4w 5% CARBON	3070101.	1121.	R0326	RESISTOR, 2150 OHM 1/4w 1% METAL FILM	3132151.	7115.
R0145	RESISTOR, 2.0 OHM 1/2w 5% CARBON	3010020.	1121.	R0330	POTENTIOMETER, 1K OHM TRIM	3110147.	71450.
R0145	RESISTOR, 100 OHM 1/4w 5% CARBON	3070101.	1121.	R0331	RESISTOR, 24300 OHM 1/4w 1% METAL FILM	3132432.	7115.
R0150	RESISTOR, 5100 OHM 1/4w 5% CARBON	3070512.	1121.	R0332	POTENTIOMETER, 10K OHM TRIM	3110150.	71450.
R0151	RESISTOR, 13K OHM 1/4w 5% CARBON	3070133.	1121.	R0333	RESISTOR, 210K OHM 1/4w 1% METAL FILM	3132103.	7115.
R0155	RESISTOR, 7500 OHM 1/4w 5% CARBON	3070752.	1121.	R0335	RESISTOR, 25K OHM 1/4w 1% METAL FILM	3072210.	7115.
R0156	RESISTOR, 10000 OHM 1/4w 1% METAL FILM	3131002.	7115.	R0340	RESISTOR, 2200 OHM 1/4w 5% CARBON	3070222.	7115.
R0157	POTENTIOMETER, 500 OHM TRIM	3110142.	71450.	R0341	RESISTOR, 68 OHM 1/4w 5% CARBON	3070680.	7115.
R0158	RESISTOR, 10000 OHM 1/4w 1% METAL FILM	3131002.	7115.	R0342	RESISTOR, 324K OHM 1/4w 1% METAL FILM	3133243.	7115.
R0160	RESISTOR, 330 OHM 1/4w 5% CARBON	3070331.	1121.	R0343	RESISTOR, 1000 OHM 1/4w 5% CARBON	3070102.	7115.
R0161	RESISTOR, 13K OHM 1/4w 5% CARBON	3070133.	1121.	R0344	RESISTOR, 332 OHM 1/4w 1% METAL FILM	3133320.	7115.
R0165	RESISTOR, 1500K OHM 1/4w 1% METAL FILM	3131502.	7115.	R0345	RESISTOR, 274K OHM 1/4w 1% METAL FILM	3132743.	7115.
R0166	POTENTIOMETER, 500 OHM PC TRIM	3110090.	80294.	R0346	RESISTOR, 274K OHM 1/4w 1% METAL FILM	3132743.	7115.
R0167	RESISTOR, 15000 OHM 1/4w 1% METAL FILM	3131502.	7115.	R0347	RESISTOR, 16500 OHM 1/4w 1% METAL FILM	3131652.	7115.
R0168	RESISTOR, 7500 OHM 1/4w 5% CARBON	3070752.	1121.	R0348	POTENTIOMETER, 5K OHM TRIM	3110149.	71450.
R0169	RESISTOR, 1500 OHM 1/4w 5% CARBON	3070152.	1121.	R0349	RESISTOR, 16500 OHM 1/4w 1% METAL FILM	3131652.	7115.
R0170	RESISTOR, 1000 OHM 1/4w 5% CARBON	3070102.	1121.	R0350	RESISTOR, 10K OHM 1/4w 5% CARBON	3070103.	7115.
R0171	RESISTOR, 10K OHM 1/4w 5% CARBON	3070103.	1121.	R0351	RESISTOR, 10000 OHM 1/4w 1% METAL FILM	3131002.	7115.
R0172	RESISTOR, SELECTED VALU			R0353	RESISTOR, 12K OHM 1/4w 5% CARBON	3070123.	7115.
R0175	RESISTOR, 2.0 OHM 1/2w 5% CARBON	3010020.	1121.	R0360	RESISTOR, 25K OHM 1/4w 1% METAL FILM	3072210.	7115.
R0185	RESISTOR, 10200 OHM 1/4w 1% METAL FILM	3131022.	7115.	R0365	RESISTOR, 160 OHM 1/4w 5% CARBON	3010161.	7115.
R0186	POTENTIOMETER, 1K OHM TRIM	3110147.	71450.	R0366	RESISTOR, 2200 OHM 1/4w 5% CARBON	3070222.	7115.
R0187	RESISTOR, 20000 OHM 1/4w 1% METAL FILM	3132002.	7115.	R0370	RESISTOR, 27 OHM 1/4w 5% CARBON	3070270.	7115.
R0188	POTENTIOMETER, 2.5K OHM TRIM	3110148.	71450.	R0371	RESISTOR, 100K OHM 1/4w 5% CARBON	3070104.	7115.
R0189	RESISTOR, 40.2K OHM 1/4w 1% METAL FILM	3134022.	7115.	R0372	RESISTOR, 10K OHM 1/4w 5% CARBON	3070103.	7115.
R0190	POTENTIOMETER, 5K OHM TRIM	3110149.	71450.	R0375	RESISTOR, 51 OHM 1/4w 5% CARBON	3070510.	7115.
R0191	RESISTOR, 80.6K OHM 1/4w 1% METAL FILM	3138062.	7115.	R0376	RESISTOR, 620 OHM 1/4w 5% CARBON	3070621.	7115.
R0195	RESISTOR, 10000 OHM 1/4w 1% METAL FILM	3131002.	7115.	R0380	RESISTOR, 22 OHM 1/4w 5% CARBON	3070220.	7115.
R0196	POTENTIOMETER, 1K OHM TRIM	3110147.	71450.	R0385	RESISTOR, 22 OHM 1/4w 5% CARBON	3070220.	7115.
R0197	RESISTOR, 19600 OHM 1/4w 1% METAL FILM	3131962.	7115.	R0386	RESISTOR, 20 OHM 1/4w 5% CARBON	3070200.	7115.
R0198	RESISTOR, 40.2K OHM 1/4w 1% METAL FILM	3134022.	7115.	R0387	RESISTOR, 1000 OHM 1/4w 1% METAL FILM	3131001.	7115.
R0199	RESISTOR, 80.6K OHM 1/4w 1% METAL FILM	3138062.	7115.	R0390	POTENTIOMETER, 250 OHM	3110145.	71450.
R0200	RESISTOR, 100K OHM 1/4w 1% METAL FILM	3131003.	7115.	R0391	RESISTOR, 2740 OHM 1/4w 1% METAL FILM	3132741.	7115.
R0201	RESISTOR, 200K OHM 1/4w 1% METAL FILM	3132003.	7115.	R0392	RESISTOR, 2740 OHM 1/4w 1% METAL FILM	3132741.	7115.
R0202	RESISTOR, 402K OHM 1/4w 1% METAL FILM	3134023.	7115.	R0393	POTENTIOMETER, 250 OHM	3110145.	71450.
R0203	RESISTOR, 806K OHM 1/4w 1% METAL FILM	3138063.	7115.	R0395	RESISTOR, 4220 OHM 1/4w 1% METAL FILM	3134221.	7115.
R0204	RESISTOR, SELECTED VALU			R0396	POTENTIOMETER, 250 OHM	3110145.	71450.
R0205							

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PARTS LIST

				EXACT NO	MFC	PART	DESCRIPTION	EXACT NO	MFC
R040C	RESISTOR,	4220	OHM 1/4W 1% METAL FILM	3134221.	7115.	R0801	RESISTOR, 100K OHM 1/4W 5% CARBON	3070104.	1121.
R040I	RESISTOR,	1000	OHM 1/4W 1% METAL FILM	3131001.	7115.	R0802	RESISTOR, 27 OHM 1/4W 5% CARBON	3070270.	1121.
R040J	RESISTOR,	3010	OHM 1/4W 1% METAL FILM	3133011.	7115.	R0805	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220.	1121.
R040S	RESISTOR,	150	OHM 1/4W 5% CARBON	3070151.	1121.	R0811	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220.	1121.
R0406	RESISTOR,	22	OHM 1/4W 5% CARBON	3070220.	1121.	R0811	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470.	1121.
R041C	RESISTOR,	150	OHM 1/4W 5% CARBON	3070151.	1121.	R0820	RESISTOR, 75.0 OHM 1/4W 1% METAL FILM	3130750.	7115.
R041I	RESISTOR,	22	OHM 1/4W 5% CARBON	3070220.	1121.	R0621	RESISTOR, 2490 OHM 1/4W 1% METAL FILM	3132491.	7115.
R041S	RESISTOR,	820	OHM 1/4W 5% CARBON	3070821.	1121.	R0822	POTENTIOMETER, 250 OHM	3110145.	71450.
R0416	RESISTOR,	2700	OHM 1/4W 5% CARBON	3070272.	1121.	R0823	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991.	7115.
R0420	RESISTOR,	150	OHM 1/4W 5% CARBON	3070151.	1121.	R0624	POTENTIOMETER, 500 OHM TRIM	3110142.	71450.
R0421	RESISTOR,	22	OHM 1/4W 5% CARBON	3070220.	1121.	R0825	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002.	7115.
R0425	RESISTOR,	150	OHM 1/4W 5% CARBON	3070151.	1121.	R0826	POTENTIOMETER, 1K OHM TRIM	3110147.	71450.
R0426	RESISTOR,	22	OHM 1/4W 5% CARBON	3070220.	1121.	R0827	RESISTOR, 20000 OHM 1/4W 1% METAL FILM	3132002.	7115.
R0427	RESISTOR,	100	OHM 1/4W 5% CARBON	3070101.	1121.	R0628	POTENTIOMETER, 1K OHM TRIM	3110147.	71450.
R0430	RESISTOR,	1600	OHM 1/4W 5% CARBON	3070162.	1121.	R0629	RESISTOR, 24900 OHM 1/4W 1% METAL FILM	3132492.	7115.
R0460	TC					R0630	POTENTIOMETER, 2K OHM PC TRIM	3110130.	78488.
R051S	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0831	RESISTOR, 49.9K OHM 1/4W 1% METAL FILM	3134992.	7115.
R052S	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0832	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003.	7115.
R0526	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0834	RESISTOR, 200K OHM 1/4W 1% METAL FILM	3132003.	7115.
R0527	RESISTOR,	1000	OHM 1/4W 5% CARBON	3070102.	1121.	R0836	RESISTOR, 249K OHM 1/4W 1% METAL FILM	3132493.	7115.
R0530	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0838	RESISTOR, 499K OHM 1/4W 1% METAL FILM	3134993.	7115.
R0531	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0840	RESISTOR, 1000K OHM 1/2W 1% METAL FILM	3101004.	7115.
R0535	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0642	RESISTOR, 2000K OHM 1/4W 5% CARBON	3070205.	1121.
R0536	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0843	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001.	7115.
R0540	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0844	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001.	7115.
R0541	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0845	RESISTOR, 4020 OHM 1/4W 1% METAL FILM	3134621.	7115.
R0550	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0651	RESISTOR, 750 OHM 1/4W 5% CARBON	3070751.	1121.
R0551	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0652	RESISTOR, 274K OHM 1/4W 1% METAL FILM	3132743.	7115.
R0552	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0653	RESISTOR, 274K OHM 1/4W 1% METAL FILM	3132743.	7115.
R0553	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0654	RESISTOR, 470 OHM 1/4W 5% CARBON	3070471.	1121.
R0557	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0655	RESISTOR, 150K OHM 1/4W 5% METAL FILM	3130652.	7115.
R0610	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0656	RESISTOR, 16500 OHM 1/4W 1% METAL FILM	3131652.	7115.
R0611	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0857	POTENTIOMETER, 5K OHM TRIM	3110146.	71450.
R0630	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0658	RESISTOR, 16500 OHM 1/4W 1% METAL FILM	3131652.	7115.
R0631	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0659	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002.	7115.
R0632	RESISTOR,	1000	OHM 1/4W 5% CARBON	3070102.	1121.	R0660	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211.	7115.
R0645	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0861	RESISTOR, 15K OHM 1/4W 5% CARBON	3070153.	1121.
R0646	RESISTOR,	20K	OHM 1/4W 5% CARBON	3070203.	1121.	R0665	RESISTOR, 11K OHM 1/4W 5% CARBON	3070113.	1121.
R0675	RESISTOR,	324	OHM 1/4W 1% METAL FILM	3133240.	7115.	R0870	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103.	1121.
R0676	RESISTOR,	121	OHM 1/4W 1% METAL FILM	3131210.	7115.	R0871	RESISTOR, 68 OHM 1/4W 5% CARBON	3070680.	1121.
R0677	POTENTIOMETER,	500	OHM TRIM	3110142.	71450.	R0875	RESISTOR, 160 OHM 1/4W 5% CARBON	3070161.	1121.
R0678	RESISTOR,	1000	OHM 1/4W 1% METAL FILM	3131001.	7115.	R0876	RESISTOR, 4300 OHM 1/4W 5% CARBON	3070432.	1121.
R0679	POTENTIOMETER,	100	OHM TRIM	3110141.	71450.	R0880	RESISTOR, 51 OHM 1/4W 5% CARBON	3070510.	1121.
R0680	POTENTIOMETER,	2K	OHM PC TRIM	3110130.	78488.	R0881	RESISTOR, 360 OHM 1/4W 5% CARBON	3070361.	1121.
R0681	RESISTOR,	22100	OHM 1/4W 1% METAL FILM	3132212.	7115.	R0885	RESISTOR, 100K OHM 1/4W 5% CARBON	3070104.	1121.
R0682	RESISTOR,	22100	OHM 1/4W 1% METAL FILM	3132212.	7115.	R0886	RESISTOR, 5600 OHM 1/4W 5% CARBON	3070562.	1121.
R0683	POTENTIOMETER,	2K	OHM PC TRIM	3110130.	78488.	R0887	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470.	1121.
R0684	RESISTOR,	75.0	OHM 1/4W 1% METAL FILM	3130750.	7115.	R0890	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150.	1121.
R0685	POTENTIOMETER,	2K	OHM PC TRIM	3110130.	78488.	R0895	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150.	1121.
R0686	RESISTOR,	17400	OHM 1/4W 1% METAL FILM	3131742.	7115.	R0900	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150.	1121.
R0687	RESISTOR,	17400	OHM 1/4W 1% METAL FILM	3131742.	7115.	R0905	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150.	1121.
R0688	POTENTIOMETER,	2K	OHM PC TRIM	3110130.	78488.	R0906	RESISTOR, 150 OHM 1/2W 1% METAL FILM	3101500.	7115.
R0689	RESISTOR,	187	OHM 1/4W 1% METAL FILM	3131870.	7115.	R0907	RESISTOR, 150 OHM 1/2W 1% METAL FILM	3101500.	7115.
R0690	POTENTIOMETER,	2K	OHM PC TRIM	3110130.	78488.	R0908	RESISTOR, 150 OHM 1/2W 1% METAL FILM	3101500.	7115.
R0691	RESISTOR,	5900	OHM 1/4W 1% METAL FILM	3135901.	7115.	R0912	RESISTOR, 475 OHM 1/4W 1% METAL FILM	3134750.	7115.
R0692	RESISTOR,	5900	OHM 1/4W 1% METAL FILM	3135901.	7115.	R0913	RESISTOR, 10500 OHM 1/4W 1% METAL FILM	3131052.	7115.
R0693	POTENTIOMETER,	2K	OHM PC TRIM	3110130.	78488.	R0914	RESISTOR, 56.2 OHM 1/4W 1% METAL FILM	3130562.	7115.
R0694	RESISTOR,	140	OHM 1/4W 1% METAL FILM	3131400.	7115.	R0916	RESISTOR, 40.2 OHM 1/8W 1% METAL FILM	3100402.	7115.
R0695	RESISTOR,	9310	OHM 1/4W 1% METAL FILM	3139311.	7115.	R0917	RESISTOR, SELECTED VALU		
R0696	RESISTOR,	9310	OHM 1/4W 1% METAL FILM	3139311.	7115.	R0918	RESISTOR, 10.0 OHM 1/4W 1% METAL FILM	3130100.	7115.
R0697	RESISTOR,	324	OHM 1/4W 1% METAL FILM	3133240.	7115.	R0919	RESISTOR, 41.2 OHM 1/8W 1% METAL FILM	3180412.	7115.
R0700	POTENTIOMETER,	500	OHM TRIM	3110142.	71450.	R0921	RESISTOR, 40.2 OHM 1/8W 1% METAL FILM	3180402.	7115.
R0701	RESISTOR,	2740	OHM 1/4W 1% METAL FILM	3132741.	7115.	R0922	RESISTOR, SELECTED VALU		
R0703	RESISTOR,	2740	OHM 1/4W 1% METAL FILM	3132741.	7115.	R0923	RESISTOR, 10.0 OHM 1/4W 1% METAL FILM	3130100.	7115.
R0704	POTENTIOMETER,	500	OHM TRIM	3110142.	71450.	R0925	RESISTOR, 41.2 OHM 1/8W 1% METAL FILM	3180412.	7115.
R0705	POTENTIOMETER,	250	OHM	3110145.	71450.	R0935	POTENTIOMETER, 500 OHM TRIM	3110142.	71450.
R0706	RESISTOR,	909	OHM 1/4W 1% METAL FILM	3139090.	7115.	R0936	RESISTOR, 2490 OHM 1/4W 1% METAL FILM	3132491.	7115.
R0710	RESISTOR,	1600	OHM 1/4W 5% CARBON	3070162.	1121.	R0937	RESISTOR, 2490 OHM 1/4W 1% METAL FILM	3132491.	7115.
R0711	RESISTOR,	274K	OHM 1/4W 1% METAL FILM	3132743.	7115.	R0938	POTENTIOMETER, 500 OHM TRIM	3110142.	71450.
R0712	RESISTOR,	274K	OHM 1/4W 1% METAL FILM	3132743.	7115.	R0939	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101.	1121.
R0713	RESISTOR,	470	OHM 1/4W 5% CARBON	3070471.	1121.	R0945	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0714	RESISTOR,	324K	OHM 1/4W 1% METAL FILM	3133243.	7115.	R0946	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0715	RESISTOR,	16500	OHM 1/4W 1% METAL FILM	3131652.	7115.	R0950	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0716	POTENTIOMETER,	5K	OHM TRIM	3110145.	71450.	R0901	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0717	RESISTOR,	16500	OHM 1/4W 1% METAL FILM	3131652.	7115.	R0975	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0718	RESISTOR,	10000	OHM 1/4W 1% METAL FILM	3131002.	7115.	R0976	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0719	RESISTOR,	332	OHM 1/4W 1% METAL FILM	3133320.	7115.	R0980	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0720	RESISTOR,	10K	OHM 1/4W 5% CARBON	3070103.	1121.	R0981	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0721	RESISTOR,	68	OHM 1/4W 5% CARBON	3070680.	1121.	R0985	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0725	RESISTOR,	15K	OHM 1/4W 5% CARBON	3070153.	1121.	R0986	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0726	RESISTOR,	12K	OHM 1/4W 5% CARBON	3070123.	1121.	R0987	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102.	1121.
R0730	RESISTOR,	2200	OHM 1/4W 5% CARBON	3070222.	1121.	R0990	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0731	RESISTOR,	160	OHM 1/4W 5% CARBON	3070161.	1121.	R0991	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0735	RESISTOR,	620	OHM 1/4W 5% CARBON	3070621.	1121.	R0995	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0736	RESISTOR,	51	OHM 1/4W 5% CARBON	3070510.	1121.	R0996	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0740	RESISTOR,	10K	OHM 1/4W 5% CARBON	3070103.	1121.	R1000	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0741	RESISTOR,	100K	OHM 1/4W 5% CARBON	3070104.	1121.	R1005	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0742	RESISTOR,	27	OHM 1/4W 5% CARBON	3070270.	1121.	R1010	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222.	1121.
R0745	RESISTOR,	22	OHM 1/4W 5% CARBON	3070220.	1121.	R1039	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102.	1121.
R0750	RESISTOR,	22	OHM 1/4W 5% CARBON	3070220.	1121.	R1040	TO		
R0751	RESISTOR,	47	OHM 1/4W 5% CARBON	3070470.	1121.	R1065	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103.	1121.
R0755	RESISTOR,	953	OHM 1/4W 1% METAL FILM	3139530.	7115.	R1070	TC		
R0756	POTENTIOMETER,	100	OHM TRIM	3110141.	71450.	R1095	RESISTOR, 20K OHM 1/4W 5% CARBON	3070203.	1121.
R0757	POTENTIOMETER,	100	OHM TRIM	3110141.	71450.	R1200	RESISTOR, 150 OHM 1/4W 5% CARBON	3070151.	1121.
R0758	RESISTOR,	953	OHM 1/4W 1% METAL FILM	3139530.	7115.	R1201	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472.	1121.
R0760	RESISTOR,	2000	OHM 1/4W 1% METAL FILM	3132001.	7115.	R1202	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220.	1121.
R0761	RESISTOR,	1910	OHM 1/4W 1% METAL FILM	3131911.	7115.	R1205	RESISTOR, 150 OHM 1/4W 5% CARBON	3070151.	1121.
R0762	POTENTIOMETER,	250	OHM	3110145.	71450.	R1206	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472.	1121.
R0765	RESISTOR,	1000	OHM 1/4W 5% CARBON						

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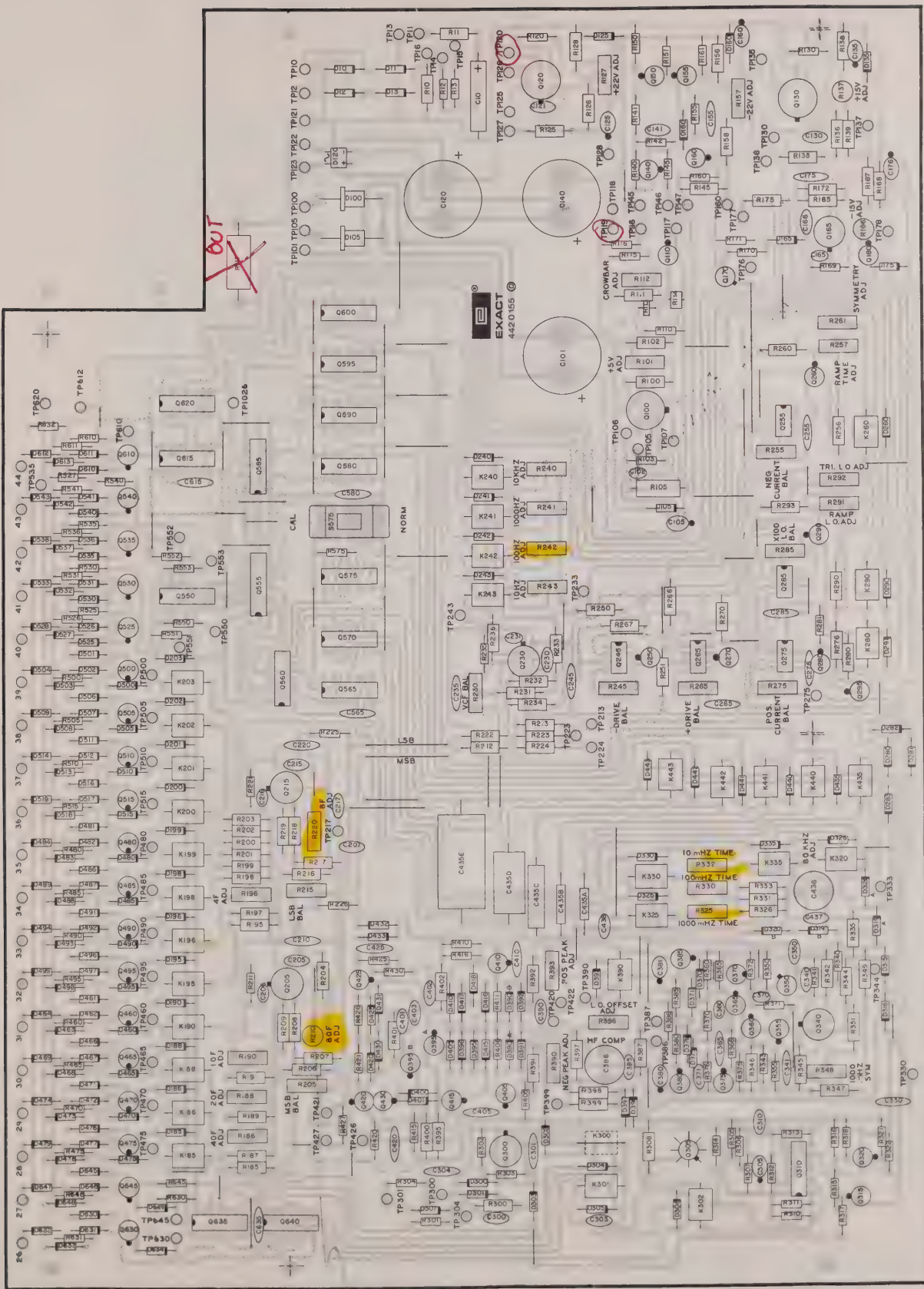
SECTION 8

PARTS LAYOUT AND SCHEMATICS

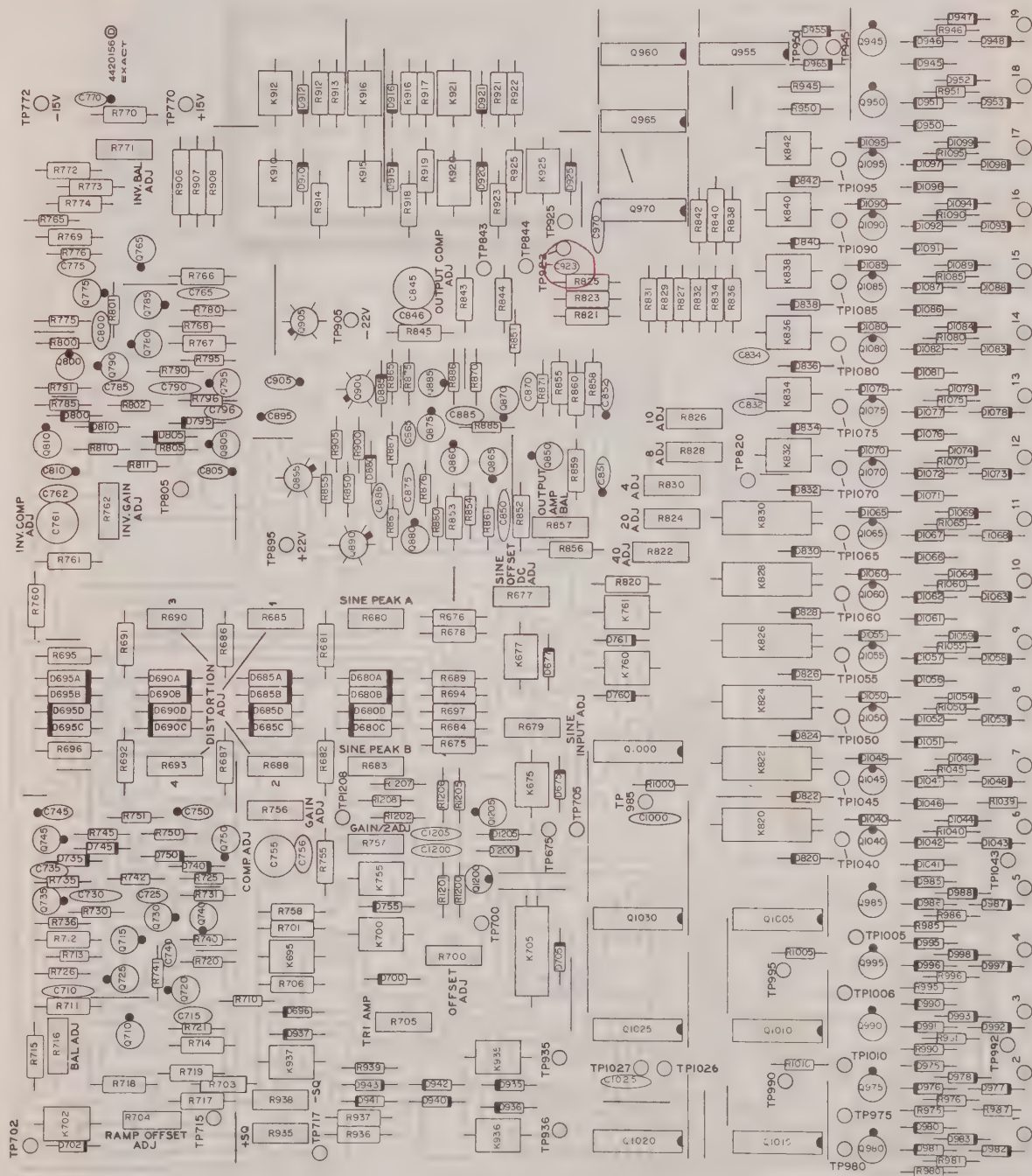
FOREWORD TO SCHEMATICS

For purposes of clarity, power supply connections to the integrated circuits used in control circuitry have been omitted. The following rules apply. All integrated circuits S/N 7400N or equivalent pin number 7 connected to programming common ∇_p , and pin number 14 connected to +5V. All integrated circuits S/N 7440N or equivalent (except Q310) pin number 7 connected to programming common, and pin number 14 connected to +5V. Q310 is isolated from program common and has its own power supply which is derived from +15V. All integrated circuits S/N 7442N or equivalent pin number 8 connected to programming common and pin number 16 connected to +5V.

To facilitate quick reference to inter-connections from one schematic to another, a system of numbers has been utilized. For instance, the relays involved in the control circuitry have relay coils on one schematic and relay contacts on another. Each schematic carries its own identifying number located in a large hexagonal shape near the title. When a connection is referred to, a small hex encompasses the number of the schematic that contains the connection.



MAIN BOARD COMPONENT LOCATIONS (fig. 8.1.0)



TOP BOARD COMPONENT LOCATIONS (fig. 8.1.1)

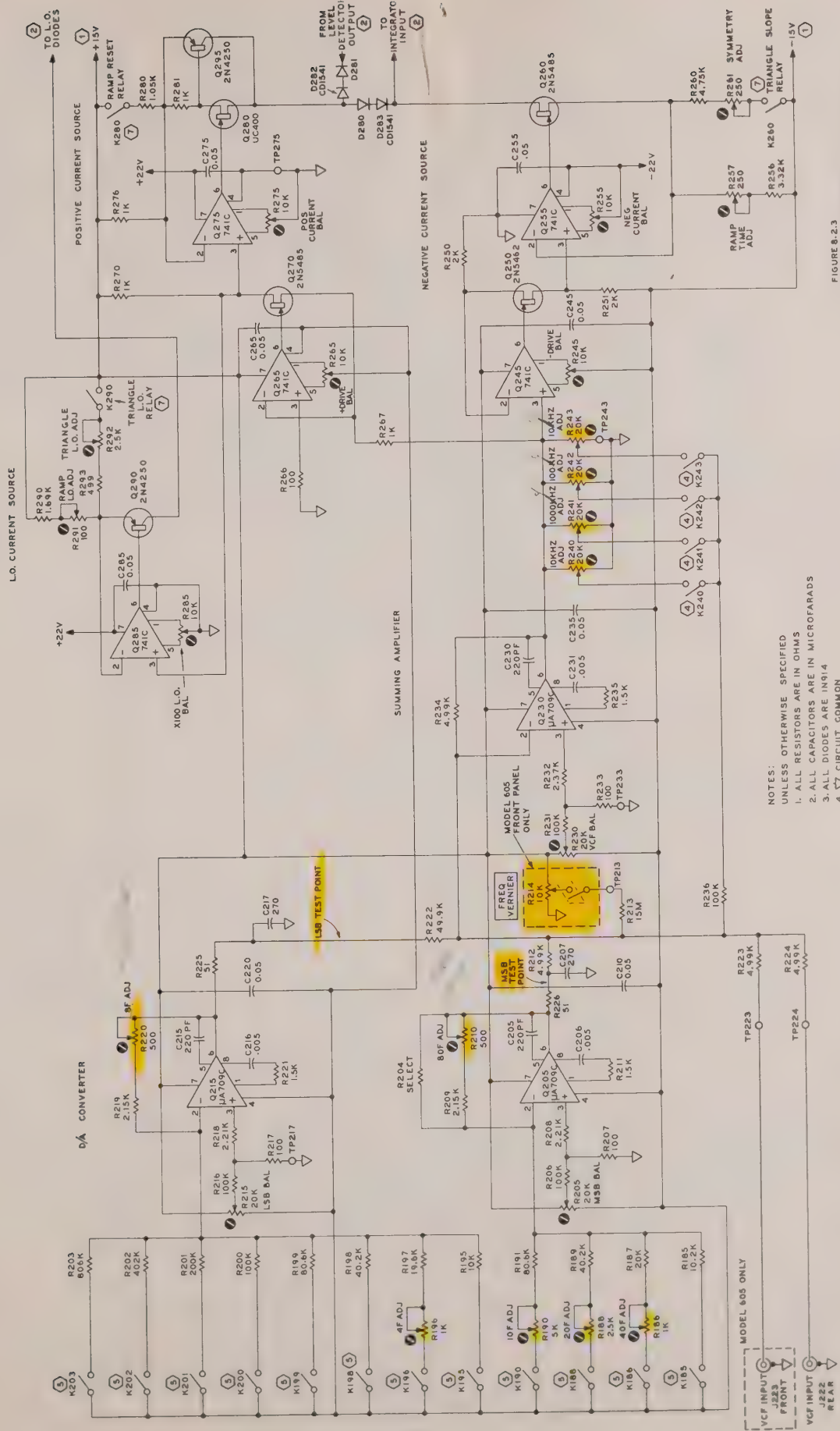
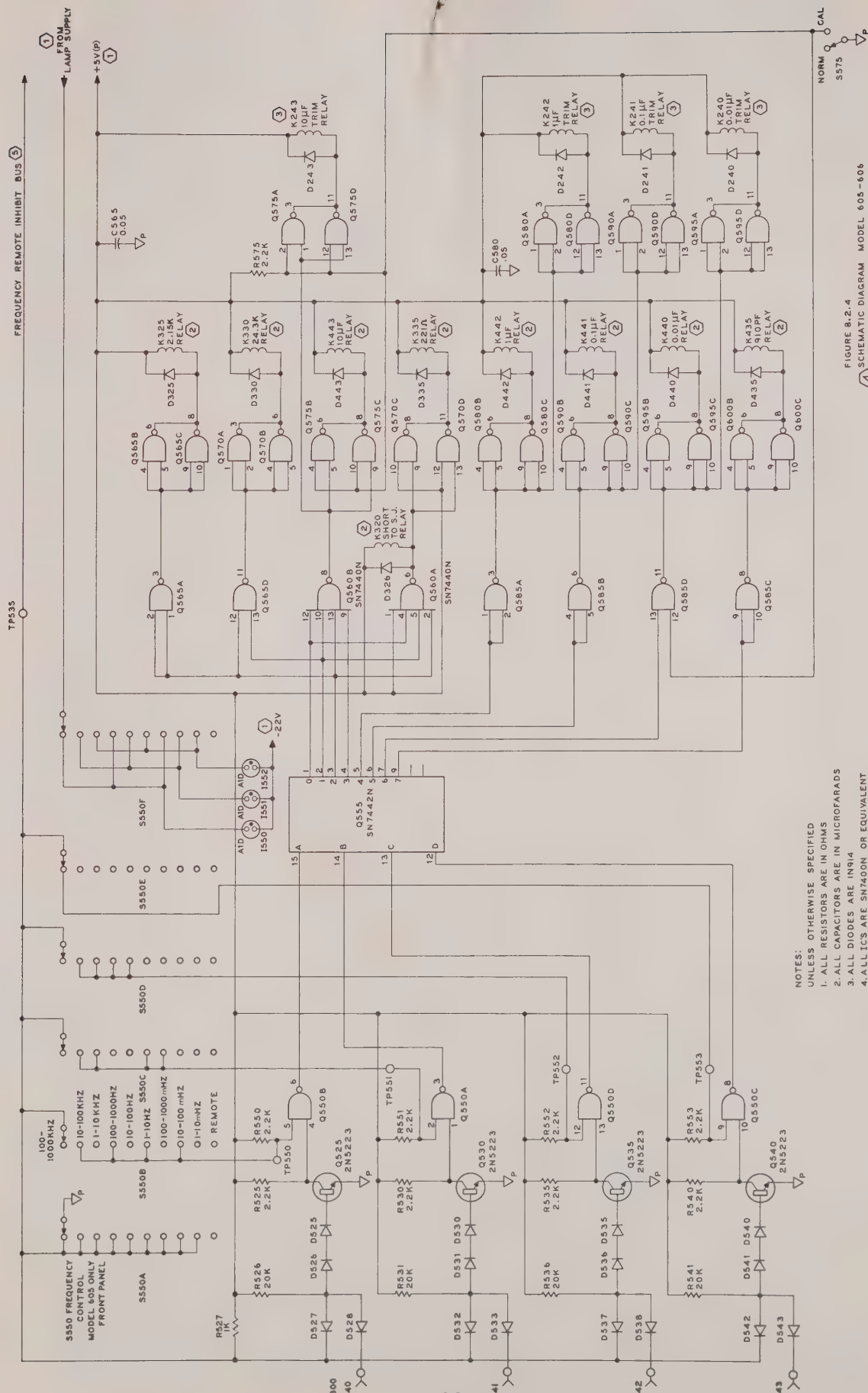
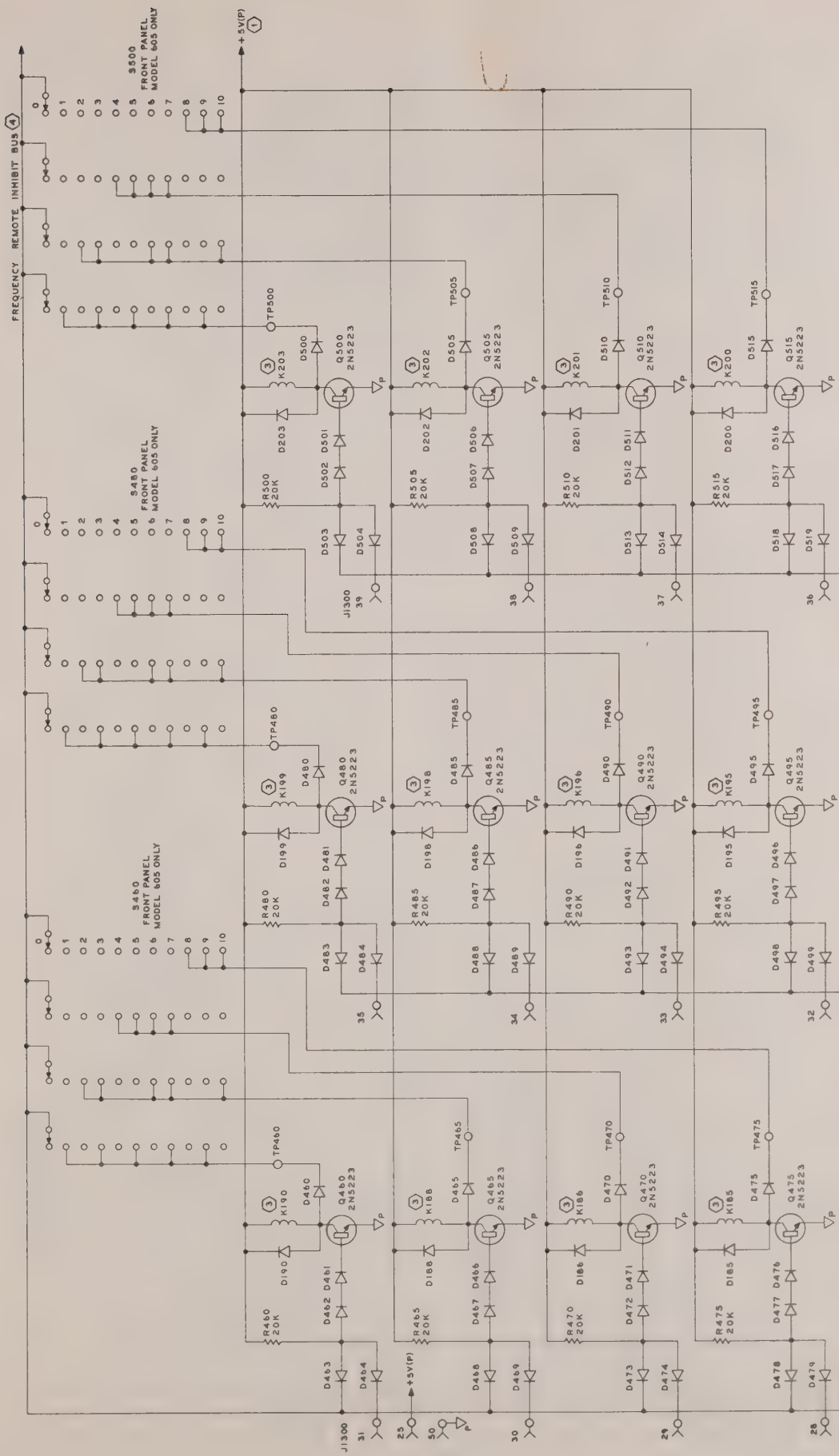


FIGURE 8.23
D/A CONVERTER & CURRENT SOURCES
11-18-70 REV C



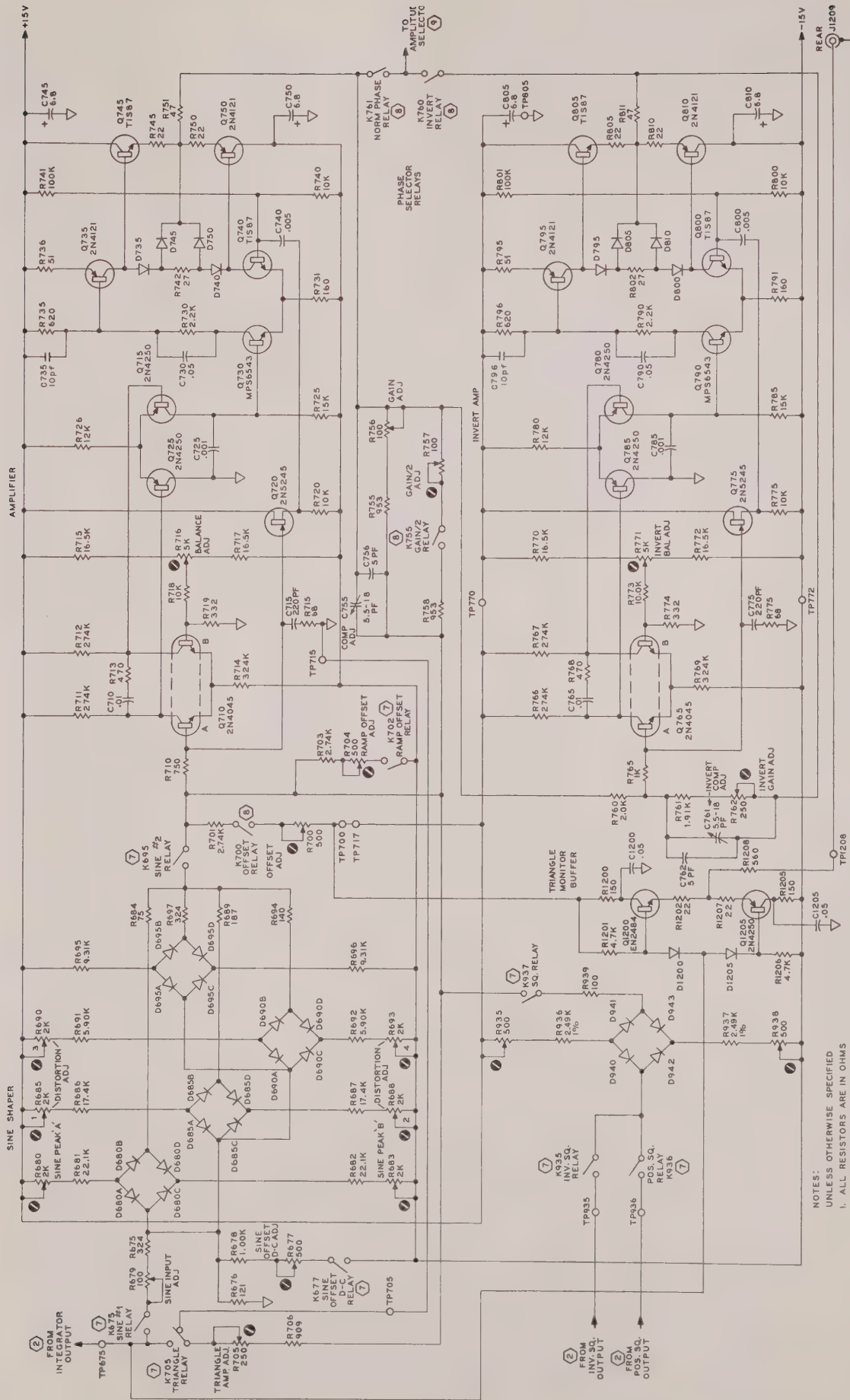
- NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS
2. ALL CAPACITORS ARE IN MICROFARADS
3. ALL DIODES ARE 1N914
4. ALL IC'S ARE SN7400N OR EQUIVALENT
5. ∇ ISOLATED PROGRAMMING COMMON
6. J1300 PROGRAMMING INPUT CONNECTOR

FIGURE 8.2.4
SCHEMATIC DIAGRAM MODEL 605-606
DECADE FREQUENCY CONTROL CIRCUIT
11-18-70 REV B



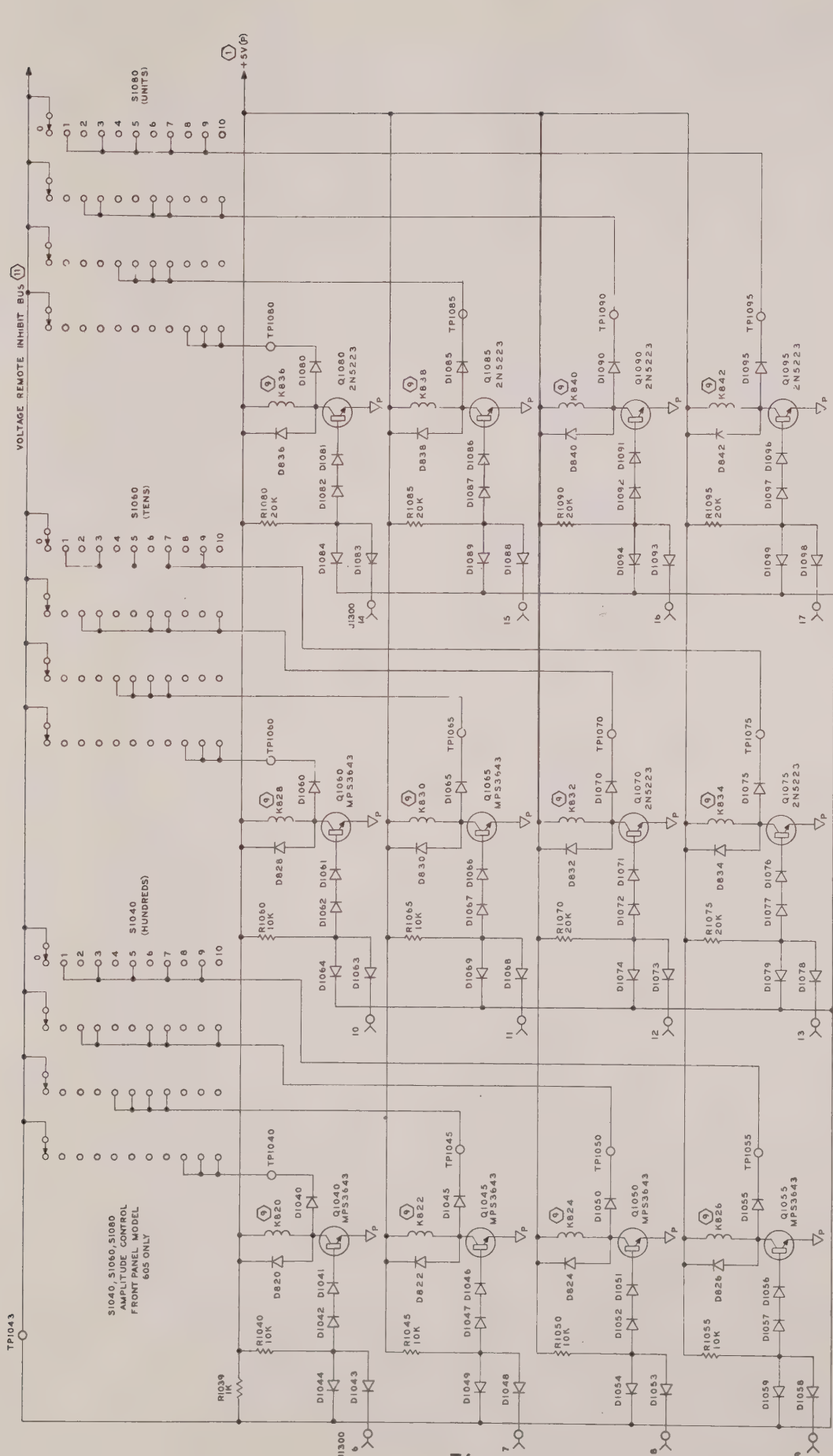
- NOTES:
1. ALL RESISTORS ARE IN OHMS
 2. ALL CAPACITORS ARE IN MICROFARADS
 3. ALL DIODES ARE IN914
 4. V_r ISOLATED PROGRAMMING COMMON
 5. J1300 PROGRAMMING INPUT CONNECTOR

FIGURE 6.2.5
SCHEMATIC DIAGRAM MODEL 605-606
FREQUENCY MULTIPLIER CONTROL CIRC
11-18-70



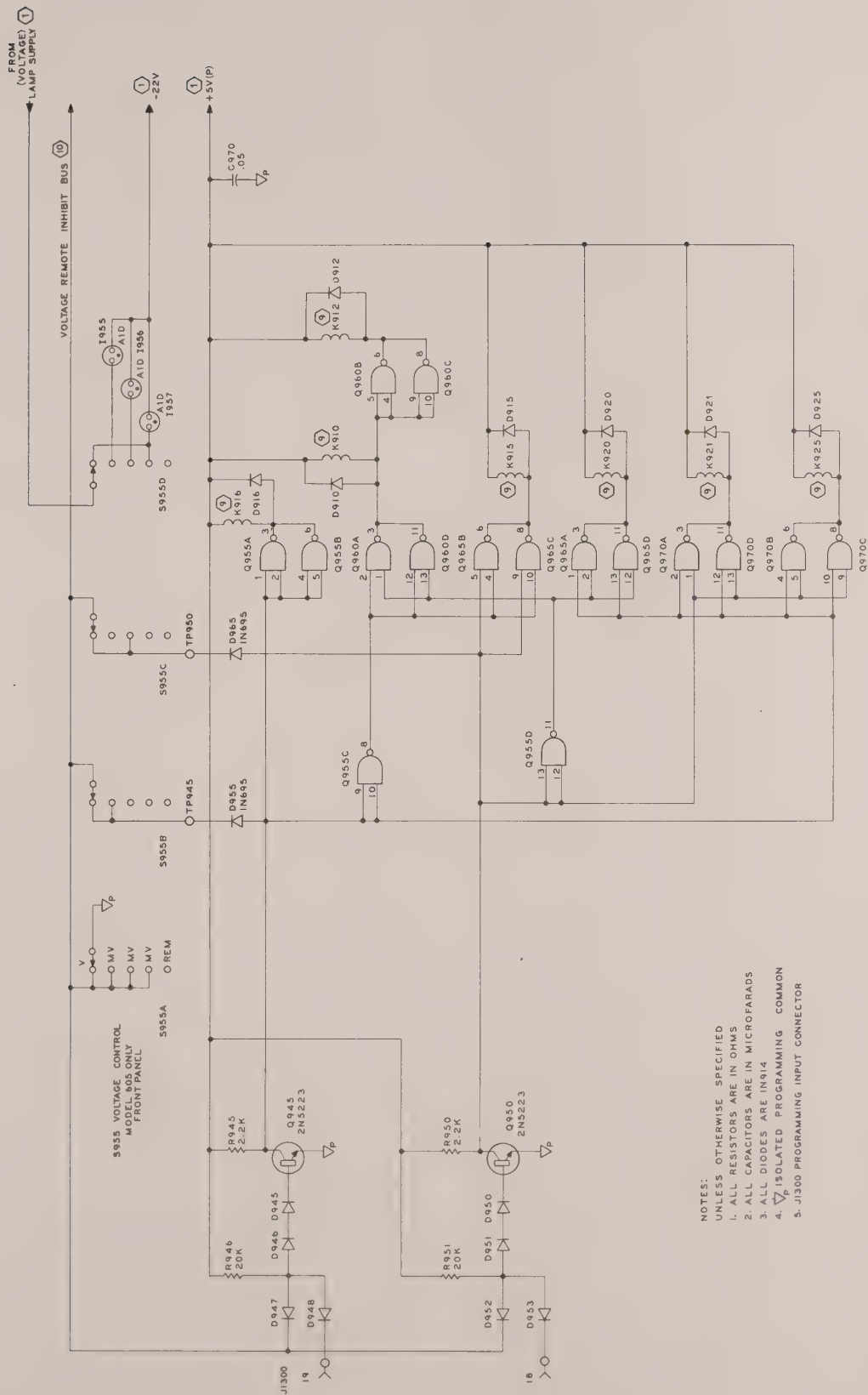
- NOTES:
1. UNLESS OTHERWISE SPECIFIED
 2. ALL RESISTORS ARE IN OHMS
 3. ALL CAPACITORS ARE IN μF
 4. ALL DIODES ARE IN94
 5. ∇ CIRCUIT COMMON

FIGURE B.2.6
SCHEMATIC DIAGRAM MODEL 605-606
AMPLIFIER AND INVERTING AMPLIFIER CIRCUITS
11-16-70 REV A



NOTES:
 UNLESS OTHERWISE SPECIFIED
 1. ALL RESISTORS ARE IN OHMS
 2. ALL CAPACITORS ARE IN MICROFARADS
 3. ALL DIODES ARE IN14
 4. ISOLATED PROGRAMMING COMMON
 5. J1300 PROGRAMMING INPUT CONNECTOR

FIGURE B.2.10
 SCHEMATIC DIAGRAM MODEL 605-401
 OUTPUT VOLTAGE CONTROL
 10-18-71



SECTION 9
ADDENDA

Calibration Procedure for Exact 605 Function Generator

This is a quick calibration procedure for adjusting the Exact model 605 function generator frequency using Self Test Seg P2 T15 9760 for the programming setup of the function generator and the counter.

- 1.) If measurement #1 fails then Adj. VCF BAL for 909 usec. $\times 1000$ Hz
- 2.) Advance through the tests until the counter displays its results in Hz or KHz.
- 3.) Set the front panel switches for 100KHz. You do not need to mess with the amplitude side of the generator. Adj. 80KHz for 100KHz.
- 4.) Set function generator for 80 KHz. The range must be changed so the most significant digit displays the 8. Adjust 80F for 80KHz.
- 5.) Set generator for 40KHz and Adj 40F for 40KHz.
- 6.) Set for 20KHz and Adj. 20F for 20KHz.
- 7.) Set for 10KHz and Adj. 10F for 10KHz.
- 8.) Return to step #1 and repeat until all readings so far performed are satisfactory.
- 9.) Set function generator for 18KHz using the two most significant digits and adjust 8F for 18KHz. This is affecting the second most significant digit (the 8) .
- 10.) Set for 14KHz and Adj. 4F for 14KHz.
- 11.) Return to step #1 and repeat through #11. This might take several go thrus to achieve.
- 12.) Return to Ms #1 and set generator for 8Hz using the most significant digit and the Hz range. Adj. 10Hz for 125000 usec.
- 13.) Set range for 80Hz and Adj. 100Hz for 12500 usec.
- 14.) Set range for 800Hz and Adj. 1000Hz for 1250 usec.
- 15.) Return to step #12 and repeat all adjustment until they all pass.
- 16.) Return to step #1 and verify that all adjustments are still good tweaking were necessary and repeating until a clean run is made with no adjustments.

SECTION 10

MODEL 605
SPECIAL 254

10.1.0 DESCRIPTION

The Special-254 modification to the EXACT Model 605 provides non-standard programming inputs and a SINE MON output which provides a rear panel SINE output all the time regardless of the position of the FUNCTION switch.

The circuitry at the beginning of the programming inputs consists of either a single transistor with diode switching on the basic input (Fig. 4.3.1) or a TTL gate which in turn drives such a circuit.

Disregard the information in 4.4 for the standard Model 605 and use instead the programming information provided in 10.2.

Pin #50 of the program input connector is the common return for all programming input connections. Pin #25 of the program input connector is a supply of +5V suitable for supplying logical "1's" to inputs held low with resistors.

In the Model 605, it is necessary to set the frequency decade control, the function selector, and voltage to the Remote position for complete remote programming.

10.2.0 PROGRAMMING TABLES

The Model 605-254 has thirty-five active inputs for programming output waveforms. With a logical "0" being defined as +.4V or less and logical "1" being defined as +2.4V or more, a truth table can be shown for generator control in response to logical "0's" and "1's". In the Model 605, the inputs and controls are grouped into three groups so that any one of the three groups can be controlled remotely or locally. Any group can be operated in either control mode without affecting the others. The three groups are as follows: frequency, function (includes trigger mode, invert and offset), and voltage. Of the three groups, "frequency" has a total of fifteen external inputs. "Function" has six inputs and "voltage" has fourteen inputs.

10.2.1 Of the fifteen inputs listed under "Frequency", three are used to control the decade range and twelve are used to control the multiplier.

The decoding for the decade range is as follows:

10.2.1 (Continued)

Pin Number Program Input Connector			Frequency Range
49	48	47	
1	1	1	10 - 100 mHz
1	1	0	100 - 1000 mHz
1	0	1	1 - 10 Hz
1	0	0	10 - 100 Hz
0	1	1	100 - 1000 Hz
0	1	0	1 - 10 KHz
0	0	1	10 - 100 KHz
0	0	0	100 - 1000 KHz

Decimal Eq.	Pin Number Program Input Connector					41 40 39 38				45 44 43 42			
	37	36	35	34									
0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	1	10	0	0	0	1	1	0	0	1
200	0	0	1	0	20	0	0	1	0	2	0	0	1
300	0	0	1	1	30	0	0	1	1	3	0	0	1
400	0	1	0	0	40	0	1	0	0	4	0	1	0
500	0	1	0	1	50	0	1	0	1	5	0	1	1
600	0	1	1	0	60	0	1	1	0	6	0	1	0
700	0	1	1	1	70	0	1	1	1	7	0	1	1
800	1	0	0	0	80	1	0	0	0	8	1	0	0
900	1	0	0	1	90	1	0	0	1	9	1	0	1
X00	1	0	1	0	X0	1	0	1	0	X	1	0	1
Binary Weight	8	4	2	1		8	4	2	1		8	4	2

Binary weight and decimal equivalent apply to standard 1248 BCD codes only.

- 10.2.2 The six inputs used to program functions can be broken down into several groups. The groups are trigger mode control (two inputs), polarity inversion (one input), fixed offset (one input), and waveform (two inputs).

The decoding table for the trigger mode control is as follows:

Pin Number of Program Input Connector

31	32	
1	0	Trigger
0	1	Gate
0	0	Run

The decoding for the polarity inversion input is as follows:

Pin Number of Program Input Connector

5	
0	Normal Output Polarity
1	Inverted Output

The decoding for the fixed offset input is as follows:

Pin Number of Program Input Connector

4	
1	Fixed Offset
0	Normal Waveform

The decoding for the waveform inputs is as follows:

Pin Number of Program Input Connector

1	2	
0	0	Sine
0	1	Triangle
1	0	Normal Square
1	1	90 Degree Sine

- 10.2.3 Of the fourteen inputs listed under Voltage Control, two are used to control the "Voltage Decade" and twelve are used for the "Voltage Multiplier."

The decoding table for the "Voltage Multiplier" is as follows:

Decimal Eq.	Pin Number Input Connector	Program	14	13	12	11	18	17	16	15
	10 9 8 7									
0	0 0 0 0	0	0	0	0	0	0	0	0	0
100	0 0 0 1	10	0	0	0	1	1	0	0	1
200	0 0 1 0	20	0	0	1	0	2	0	0	1
300	0 0 1 1	30	0	0	1	1	3	0	0	1
400	0 1 0 0	40	0	1	0	0	4	0	1	0
500	0 1 0 1	50	0	1	0	1	5	0	1	0
600	0 1 1 0	60	0	1	1	0	6	0	1	1
700	0 1 1 1	70	0	1	1	1	7	0	1	1
800	1 0 0 0	80	1	0	0	0	8	1	0	0
900	1 0 0 1	90	1	0	0	1	9	1	0	0
X00	1 0 1 0	X0	1	0	1	0	X	1	0	1
Binary Weight	8 4 2 1		8	4	2	1		8	4	2

Binary weight and decimal equivalent apply to standard 1248 BCD codes only.

The decoding for the "Voltage Decade" is as follows:

Pin Number of	Program	Input Connector
21	20	
0	0	10 - 100mv
0	1	100 - 1000mv
1	0	1 - 10V

10.2.4 JUMPERS W1 AND W2

Jumper W1 selects OFFSET for 90 DEGREE SINE which produces a SINE^2 function (except that frequency does not automatically double).

Jumper W2 selects TRIGGER MODE for 90 DEGREE SINE.

Either or both of these interactions can be eliminated by removal of the appropriate jumper.

10.3.0 SINE MON

The SINE MON output provides a constant amplitude sine output at the frequency specified by the FREQUENCY RANGE and FREQUENCY MULTIPLIER controls.

10.4.0 605-254 CALIBRATION PROCEDURE

The digital portion of the 605-254 Special board needs no calibration, but the SIN MON portion requires two adjustments.

10.4.1 EQUIPMENT REQUIRED

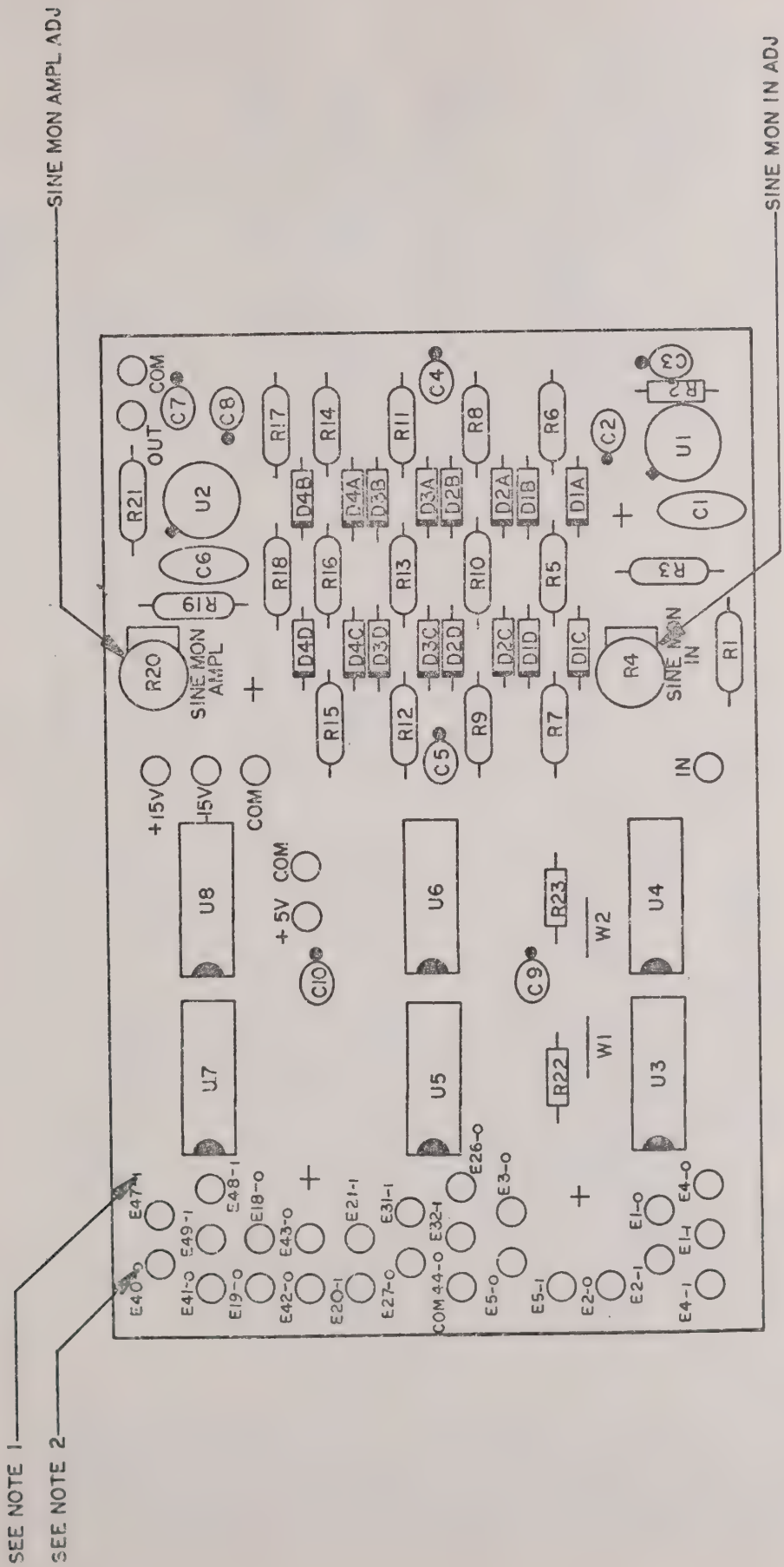
Oscilloscope with differential measurement capability.
Distortion Analyzer.

10.4.2 INITIAL CONTROL SETTINGS

POWER	ON
FREQUENCY	800Hz
VOLTAGE	9.99V
TRIGGER MODE	RUN

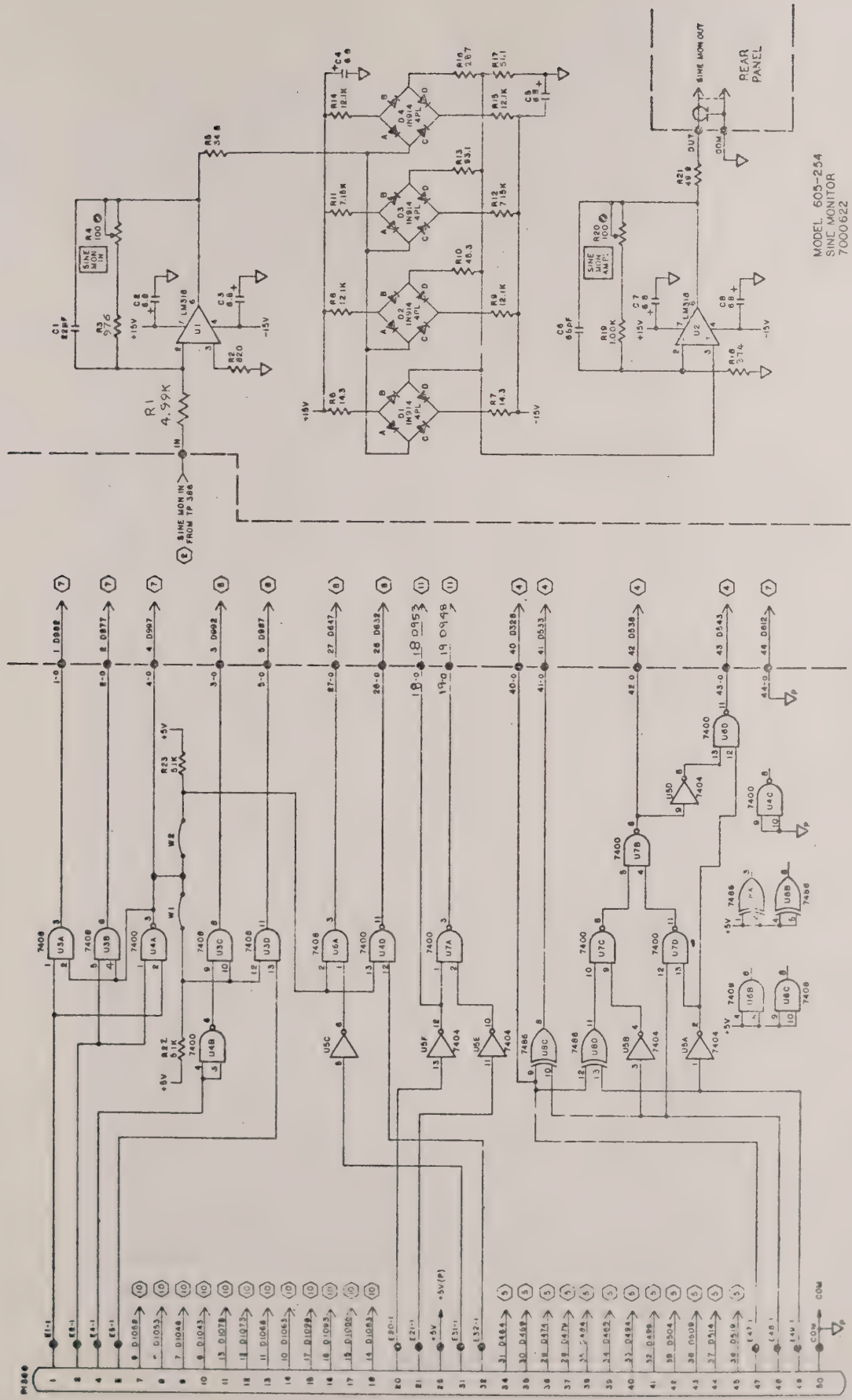
10.4.3 CALIBRATION (Refer to Component Layout 605-254)

1. Connect SIN MON to distortion analyzer and adjust SINE MON IN for minimum distortion.
2. Connect SINE MON OUT to scope with a 50 Ω load and adjust SINE MON AMPL for 1V P-P $\pm$ 25mv.



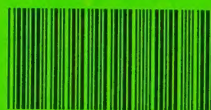
- NOTES:
1. SMALL '1' INDICATES CONNECTIONS TO J1300.
 2. SMALL 'o' INDICATES CONNECTIONS TO TURRETS CN' BOARDS INSIDE INSTRUMENT.

ADJUSTMENT LOCATION DETAIL



PART	DESCRIPTION	EXACT NO.	MFG.
C0001	CAPACITOR, 22PF MICA	2810530	853
C0002	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
C0003	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
C0004	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
C0005	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
C0006	CAPACITOR, 68PF MICA	2810530	853
C0007	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
C0008	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
C0009	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
C0010	CAPACITOR, 6.8 MFD, 35 VOLT	2900043	100002
D0001	QD, DIODE, MATCH, IN914	1530914	10597
D0002	QD, DIODE, MATCH, IN914	1530914	10597
D0003	QD, DIODE, MATCH, IN914	1530914	10597
D0004	QD, DIODE, MATCH, IN914	1530914	10597
R0001	RESISTOR, 4.99K OHM 1/4W 1%	3134991	7115
R0002	RESISTOR, 820 OHM 1/4W 5%	3070821	01121
R0003	RESISTOR, 976 OHM 1/4W 1%	3139760	7115
R0004	POTENTIOMETER, 100 OHM TRIM	3110345	71450
R0005	RESISTOR, 34.8 OHM 1/4W 1%	3130348	7115
R0006	RESISTOR, 14.3K OHM 1/4W 1%	3131432	7115
R0007	RESISTOR, 14.3K OHM 1/4W 1%	3131432	7115
R0008	RESISTOR, 12.1K OHM 1/4W 1%	3131212	7115
R0009	RESISTOR, 12.1K OHM 1/4W 1%	3131212	7115
R0010	RESISTOR, 45.3 OHM 1/4W 1%	3130453	7115
R0011	RESISTOR, 7.15K OHM 1/4W 1%	3137151	7115
R0012	RESISTOR, 7.15K OHM 1/4W 1%	3137151	7115
R0013	RESISTOR, 93.1 OHM 1/4W 1%	3130931	7115
R0014	RESISTOR, 12.1K OHM 1/4W 1%	3131212	7115
R0015	RESISTOR, 12.1K OHM 1/4W 1%	3131212	7115
R0016	RESISTOR, 287 OHM 1/4W 1%	3132870	7115
R0017	RESISTOR, 51.1 OHM 1/4W 1%	3130511	7115
R0018	RESISTOR, 374 OHM 1/4W 1%	3133740	7115
R0019	RESISTOR, 1K OHM 1/4W 1%	3131001	7115
R0020	POTENTIOMETER, 100 OHM TRIM	3110345	7115
R0021	RESISTOR, 49.9 OHM 1/4W 1%	3130499	7115
R0022	RESISTOR, 5.1K OHM 1/4W 5%	3070512	01121
R0023	RESISTOR, 5.1K OHM 1/4W 5%	3070512	01121
40001	INTEGRATED CIRCUIT, LM 318	1580318	12040
40002	INTEGRATED CIRCUIT, LM 318	1580318	12040
40003	INTEGRATED CIRCUIT, SN7408N	1580037	1295
40004	INTEGRATED CIRCUIT, SN7400N	1580011	1295
40005	INTEGRATED CIRCUIT, SN7404N	1580004	1295
40006	INTEGRATED CIRCUIT, SN7408N	1580037	1295
40007	INTEGRATED CIRCUIT, SN7400N	1580011	1295
40008	INTEGRATED CIRCUIT, SN7486N	1580035	1295
ZZZZ	SPACER HEX 6-32 X 1/4 X 1	3580044	10597
ZZZZ	PCB, SINE MON	4420315	10597

MP MASTER



MA29303